Sacramento River Watershed Program

Water Quality Management Strategies: Issue Summaries

DRAFT document

Sacramento River Watershed Program
Stakeholder Questionnaire
on
Water Quality Issues and Management Strategies

DRAFT document

The Toxics Subcommittee of the Sacramento River Watershed Program needs your comments on water quality issues that are important to you! The Toxics Subcommittee is planning to develop management strategies to address priority water quality problems. The first two issues will be selected, in part, on the basis of severity of the water quality problems, either to humans or the ecosystem; ability of the Sacramento River Watershed Program to alter current conditions; and opportunities to join with other organizations to solve the problem.

This document, "Development of Water Quality Management Strategies Part One: Issue Summaries", presents information gathered by members of the Toxics Subcommittee about important water quality issues and waterbodies that are affected. It also contains evaluations of each issue prepared by the Toxics Subcommittee based on this information.

Using this questionnaire, the Toxics Subcommittee would like to hear your opinions about their evaluation of the issues and any additional information you may have about water quality conditions.

Please return the questionnaire by <u>July 15, 1999</u> to:

Val Connor
Central Valley Regional Water Quality Control Board
3443 Routier Road, Suite A
Sacramento Ca 95827-3098

fax: 916 - 255 - 3015

Thank you very much for your continued participation in the Sacramento River Watershed Program.

Sacramento River Watershed Program
Water Quality Issues and Management Strategies
Stakeholder Questionnaire, March 1999

1. What do you think of the overall plan described in the Introduction for SRWP's development of water quality management strategies? Are there questions about management strategy development and/or implementation that you would like addressed in the Newsletter or at a General Stakeholder meeting?

2. Is there a water quality issue of concern to you that was not presented in the Issue Summaries? If so, please describe the issue, explain what adverse effects it is having on water quality and identify waterbodies where this is an important issue.

3. Is there additional information about any of the issues summarized in the document, that should be mentioned either in the summary text or in the evaluation table?

4. Do you have additional information about waterbody conditions, either good or bad? If so, please describe the information and how the data can be made available to the SRWP Toxics Subcommittee.

5. Please rate each of the water quality issues presented in the Issue Summaries, as to their importance to you. Please indicate whether your responses are for the entire Sacramento River Watershed or for a particular, smaller watershed or waterbody. This information will be compiled, reported, and considered in the selection of SRWP's next priority water quality issues.

_____ Responses are for the entire Sacramento River Watershed

_____ Responses are for a smaller watershed or waterbody

Identify watershed or waterbody: ____

Water Quality Issue	Importance of the Water Quality Issue			
	Very Important	Important, but less so than other issues	Minor concern	Not a concern at all
Mercury bioaccumulation				
Bioaccumulation of PCBs & organochlorines				
Drinking Water Parameters:				
organic carbon				
total dissolved solids				
pathogens				
turbidity				
Excess nutrients				
Metals:				
arsenic				
cadmium				
chromium				
copper				
lead				

nickel				
selenium				
silver				
zinc				
Pesticides:				
organophosphates				
others (name:				
Sedimentation				
Temperature				
Aquatic life toxicity due to sediment contamination				
Aquatic life toxicity due to unknown sources				

6. Would you agree with the selection of mercury and organophosphate pesticide toxicity as the focus for development of SRWP's first two water quality management strategies? If the answer is no, please describe your reasons for disagreement.

In order to direct its efforts and funding to where they will be most effective, the SRWP Toxics Subcommittee would like its information about conditions in waters of the Sacramento River Basin to be as complete as possible.

If you would be willing to have someone from the Toxics Subcommittee contact you about answers to this survey (for example, if you describe sedimentation as not a concern in a waterbody for which we have no current knowledge), please provide the following information:

Name ____

Address ____

City ______________________ State ______ Zip ________

phone ____

email ____

Sacramento River Watershed Program

Water Quality Management Issue Summaries

DRAFT document

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Introduction

The Sacramento River Watershed Program (SRWP) began in 1996. Over the past year, the SRWP Toxics Subcommittee has examined existing studies of water quality issues of concern in the Sacramento River Watershed. The Toxics Subcommittee obtained information from state and federal agencies, local and regional monitoring programs and published literature. Water quality data collected through the SRWP's Monitoring Program is becoming available to the Toxics Subcommittee as well. Now is the time to employ the information that is being gathered to assist in solving problems affecting water use and aquatic ecosystem health. The SRWP is currently looking toward its next major technical project, which is to develop management strategies for addressing priority water quality problems. The SRWP Toxics Subcommittee has established the following objectives:

> To identify key problems, opportunities for action, sources of toxic constituents of concern and waterbodies of concern, and
>
> To develop and propose strategies to control toxic constituents of concern.

The Toxics Subcommittee would like to create an interest-based, stakeholder-driven effort to meet these objectives in the Sacramento River Watershed.

This document, "Development of Water Quality Management Strategies Part 1: Issue Summaries", is the second step in presenting and prioritizing water quality issues (The first step, "Toxicants in Surface Waters of the Sacramento River Watershed" is a 400-page compilation of existing water quality information available from the SRWP). "Issue Summaries" presents information about water quality problems, the SRWP Toxics Subcommittee's recommendations for the issues to be considered initially, draft management plans for those two issues, and a questionnaire. In order to proceed further, the SRWP Toxics Subcommittee needs comments from other stakeholders regarding water quality issues of concern not included in these summaries and the recommendations made by members of the Toxics Subcommittee. **Please review this document, and return any opinions and additional information that we may have overlooked using the questionnaire provided.**

The first section of this document, "Issue Summaries", provides a brief description of significant water quality issues of concern in the Sacramento River Watershed. Individual summaries were drafted by members of the Toxics Subcommittee, then reviewed by other members of the Toxics Subcommittee and Public Outreach and Education Subcommittee. The summaries were edited to incorporate comments and additional information. At the end of each summary is an evaluation table. The criteria and evaluations were prepared during a Toxics Subcommittee meeting. The evaluation represents the opinions of the Toxics Subcommittee on the relative significance of the water quality issues and the feasibility of producing effective management strategies. The ability to make progress on addressing the issue and the existence of possibilities for combining SRWP's efforts and funding with those of other organizations were very important criteria.

The second section of the document explains the recommendation of two of the water quality issues, mercury and organophosphate pesticides, to be the first ones for which SRWP will develop management strategies. Opportunities are available now for the SRWP to join with other watershed groups and CALFED in addressing the issue of mercury and with the Central Valley Regional Water Quality Control and the Department of Pesticide Regulation in addressing aquatic toxicity due to organophosphate pesticides.

The third section describes the decision to focus part of the Toxics Subcommittee's efforts on acquiring additional information about two water quality issues, drinking water constituents and unknown toxicity. These are also considered priority water quality issues of concern, but further information is needed to define particular water quality constituents and where problems are occurring. Toxicity from unknown sources currently impacts beneficial uses of the Sacramento River and tributaries, but causes of the toxicity need to be identified. Drinking water contaminants, especially pathogens, are or may become concerns of stakeholders throughout the watershed. Sources and waterbodies impacted most severely by drinking water contaminants also need to be identified. Additional information is needed in order to determine whether management strategies are needed for these two issues.

The diagram on page five shows graphically the elements the Toxics Subcommittee proposes to use to develop and implement water quality management strategies. The process is cyclical, because as new information is generated through monitoring by SRWP and other organizations, this information will be incorporated into the management options and into determining which waterbodies should receive attention. Each water quality issue summary names waterbodies that are identified as impaired on the Clean Water Act 1998 303(d) List of Impaired Waterbodies. A complete "Waterbody Report Card" will utilize all sources of water quality information available, including those shown in the lower right of the diagram.

Funding has been allocated through the Sacramento River Toxic Pollutant Control Program budget to develop water quality management strategies. Work to identify priority water quality issues and impaired waterbodies has already begun under the direction of the SRWP Toxics Subcommittee, as shown in this document. A preliminary report presenting SRWP's beginning plans for two priority water quality concerns will be completed by December, 1999. The management strategies for these two concerns will be finalized during Phase IV of the SRWP and beyond. Demonstration or early implementation projects that serve as examples of how the management strategies may be implemented are also scheduled to occur in Phase IV. It is likely both development of management strategies and implementation by SRWP will be coordinated with efforts of other organizations and with other funding sources, in order to maximize the effectiveness of SRWP's time and dollars. The timeline for Phase IV activities is expected to be April, 1999 through September, 2001. A total of $771,200 of the Phase IV allocation has been set aside for water quality management strategies and the demonstration projects. Last October, the US Congress approved money for Phase V of the SRWP.

Stakeholder Questionnaire

As mentioned above, the SRWP Toxics Subcommittee is requesting comments from other stakeholders on water quality management issues. The Toxics Subcommittee would particularly like to receive responses regarding:

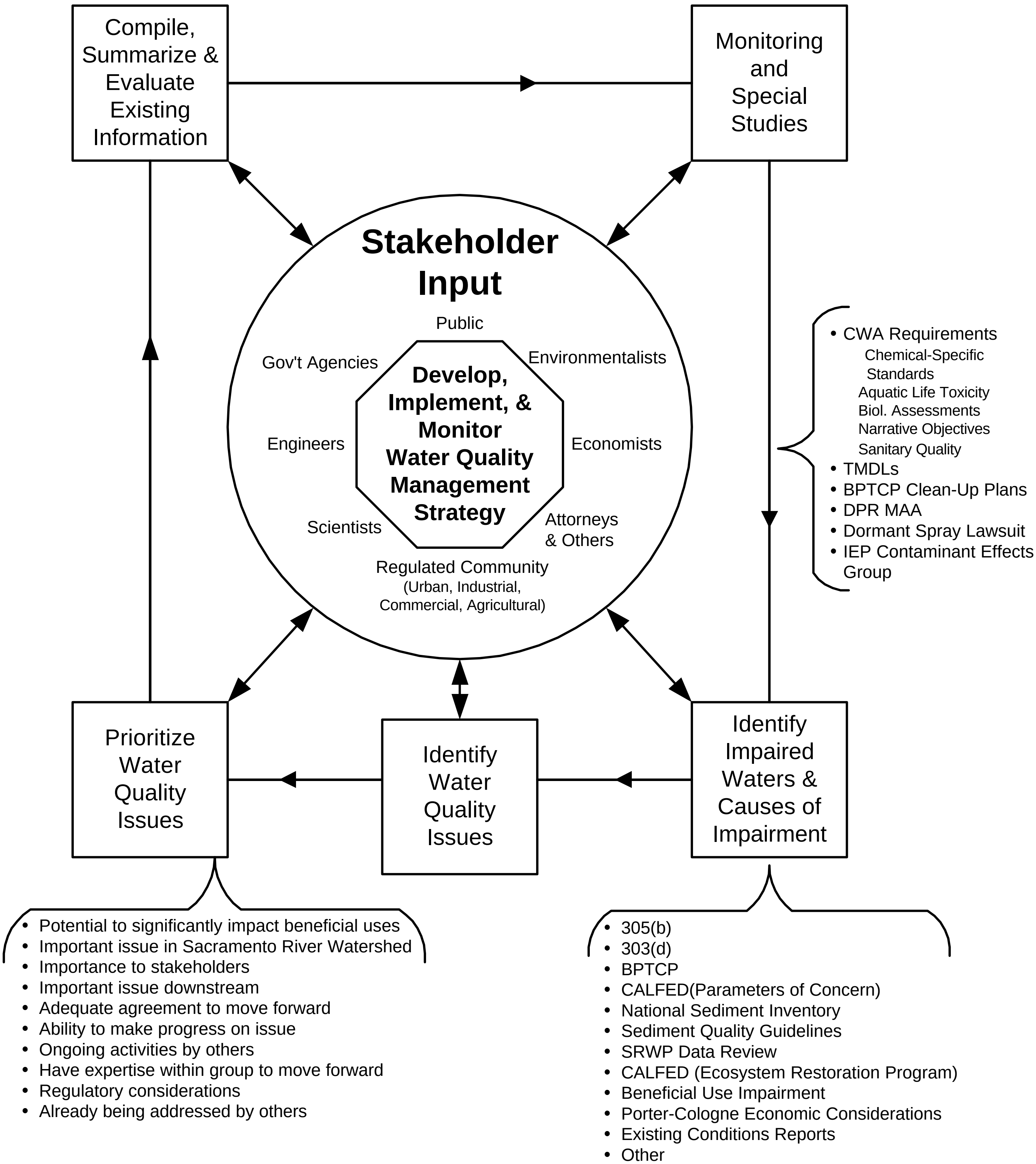
- SRWP's suggested, overall strategy for addressing water quality problems,
- information provided in the summaries of water quality issues of concern,
- additional information that is not included in these summaries about water quality issues and conditions within particular waterbodies, whether good or needing remediation,
- the evaluations of relative importance and feasibility prepared by the SRWP Toxics Subcommittee, which led to the recommendations of the two priority issues, and
- relative importance of water quality issues to each stakeholder responding.

Stakeholder comments will be presented and responded to in the final version of this document, to be released before December 1999. Additional information provided on water quality issues or impacted waters will also be included in the final version. Comments will be used to educate the Toxics Subcommittee about concerns held by other stakeholders in the Watershed. Because of the consensus that exists among SRWP stakeholders who participated in preparing this document that the two recommended issues (mercury and organophosphate pesticide toxicity) are severe water quality problems and because opportunities exist now for collaboration between other organizations addressing these problems, the SRWP Toxics Subcommittee is suggesting that these remain the first two problems addressed. Stakeholder responses will help determine the focus of SRWP's future management strategy efforts.

DRAFT Sacramento River Watershed Water Quality Management Strategy

GOAL: Formulate and Implement a technically valid, cost effective and protective water quality management strategy for a Watershed-Based Water Quality Management Program

Feedback between different tasks will be an integral part of development of water quality management strategies. For example, lists of priority issues and impaired waters will be re-evaluated as new data are collected through the SRWP monitoring program



List of Abbreviations and Definitions

AFRP	Anadromous Fish Restoration Program (a program led by US Fish and Wildlife Service)
BMP	best management practices
BPTCP	Bay Protection and Toxic Cleanup Program (a program State Water Resources Control Board and Regional Board to identify toxic hot spots in the Bay and Delta and develop plans for clean-up)
CALFED	the CALFED Bay Delta program (a joint State of California-Federal program to address water quantity and ecosystem health concerns in the San Francisco Bay Delta)
CMP	Sacramento Coordinated Water Quality Monitoring Program (a joint program of the Sacramento Regional County Sanitation District, the County of Sacramento and the City of Sacramento to monitor water quality in the American and Sacramento Rivers)
CVPIA	Central Valley Project Improvement Act, passed in 1992
CUWA	California Urban Water Agencies
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Clean Water Act (federal act passed in 1972 and amended multiple times since then)
DBP	disinfection by-product (produced when organic carbon in drinking water supply combines with disinfectants of chlorine or ozone. Some disinfection by-products are carcinogenic)
DFG	Department of Fish and Game, California
DHS	Department of Health Services, California
DO	dissolved oxygen
DOC	dissolved organic carbon
DPR	Department of Pesticide Regulation, California
DWR	Department of Water Resources, California
ICR	Information Collection Rule (a USEPA program requiring utilities to monitor their raw and treated water for pathogens)
IEP	Interagency Ecological Program

MWQI	Municipal Water Quality Investigations (a DWR program for assessing drinking water quality)
NAWQA	National Water Quality Assessment (a USGS program that measures contaminants in surface and ground water, sediment, fish tissue and assesses benthic macroinvertebrate community health. Intensive sampling period for Sacramento River Basin is 1995-1998.)
NRCS	National Resource Conservation Service
NTU	Nephelometric Turbidity Units (a unit of measure of turbidity in the water column)
OEHHA	Office of Environmental Health Hazard Assessment, California
OP	organophosphate pesticide
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RCD	Resource Conservation District
SFB RMP	San Francisco Bay Regional Monitoring Program
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SRTPCP	Sacramento River Toxic Pollutant Control Program
SRWP	Sacramento River Watershed Program
SWRCB	State Water Resources Control Board
SWTR	Surface Water Treatment Rule
TDS	total dissolved solids
TIE	toxicity identification evaluation (toxicity testing method in which specific compounds or classes of compounds causing toxicity are identified)
TMDL	total maximum daily load (See 303(d) list for explanation)
TOC	total organic carbon
USBR	US Bureau of Reclamation
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
WQC	water quality criteria

WY	water year
303(d) List	The Clean Water Act Section 303(d) List of Impaired Water Bodies. Every two years, the California Regional Water Quality Control Boards are required by the federal Clean Water Act to adopt lists of impaired waterbodies. These lists are then approved by US EPA. Concern about 303(d) listings is high, in part because of upcoming TMDL development. The Clean Water Act requires that for each contaminant in each waterbody on the 303(d) list, there be prepared a Total Maximum Daily Load (TMDL). The TMDL would identify the maximum amount of contaminant allowed in the waterbody that would not harm any beneficial uses of that waterbody (such as contact recreation, drinking water, irrigation, fisheries, aquatic life health, etc.). The TMDL process involves identifying sources, quantification of the amount of contaminant reduction needed, allocating the amount of contaminant each source can discharge to the waterbody, development of implementation plans, and approval of the entire TMDL package by the Regional Water Quality Control Board, State Water Resources Control Board and USEPA.

Water Quality Management Issue: Bioaccumulation of Toxic Constituents

Tom Grovhoug, Larry Walker Associates (Davis, Ca)

I. PROBLEM STATEMENT

Certain chemical constituents are retained in the tissues of aquatic organisms. Such chemicals may be picked up through various mechanisms (e.g. ingestion, respiration, or direct contact). This retention in tissues is termed *bioaccumulation*. Some bioaccumulative chemicals also increase in concentration in tissues of animals that are higher in the food chain. The increase in concentration up the food chain is termed *biomagnification*.

Chemicals which bioaccumulate and biomagnify and have been observed at levels of concern in the Sacramento River watershed include mercury, polychlorinated biphenyls (PCBs), and chlorinated pesticides (e.g. chlordane, toxaphene, DDT). The forms of concern for these chemicals are those that are bioavailable or are transformed to bioavailable forms in the natural environment. For instance, mercury can be present in the environment in a number of different organic and inorganic molecular forms, but methyl mercury is the form which bioaccumulates and produces adverse effects.

Problems may result from excessive accumulations of chemical constituents in the tissues of organisms. These problems may include adverse effects on reproduction, development or survival of the organism and/or adverse effects on consumers of these organisms (e.g. humans, birds, other wildlife and fish). Direct evidence of these adverse effects has not been documented in the Sacramento River watershed. Instead, problems have been inferred from chemical concentration data in fish tissue.

Type of Problem

The problems resulting from bioaccumulation of toxic constituents in aquatic organisms include both human health and ecosystem concerns. For mercury, the consumption of fish that have elevated levels of mercury may result in adverse effects in humans. The greatest concern relates to the consumption of fish by pregnant women and resulting developmental effects in newborn children. Fish consumption advisories have been issued by the California Office of Environmental Health Hazard Assessment (OEHHA) for the Bay and Delta in 1994 based on concerns for levels of mercury in some species of fish. Specifically, adults are advised to limit consumption of sport fish from the Bay to two times per month, pregnant or nursing women and children under six should limit consumption to one time per month, and large shark and striped bass should not be consumed. OEHHA has also issued advisories against human consumption of some fish species in Lake Berryessa, Clear Lake and the entire Sacramento-San Joaquin Delta, due to high tissue mercury levels.

The Toxic Substances Monitoring Program, jointly run by the State Water Resources Control Board and the Department of Fish and Game, has monitored concentrations of mercury, PCBs and chlorinated pesticides in aquatic life of the Sacramento River at Hood, the Delta and San Francisco Bay for over ten years. In 1995-1998, USGS conducted intensive sampling under the NAWQA program, which included fish tissue analysis. USGS found levels of mercury greater than 0.5 ppm in some bottom-feeding fish from the Sacramento, American and Yuba Rivers (Domagalski, 1998). Predatory fish species (squawfish, crappie, and small and large mouth bass) in lower Cache Creek have exhibited mercury tissue levels of 0.4 - 0.9 ppm (Davis, 1998; Slotton 1997). SRWP Monitoring program data shows mercury levels were near or above 0.5 ppm in white catfish from the American River at Discovery Park, the Sacramento River near Woodland, and Cache Slough (see Issue Six of the SRWP newsletter "Waterways" for 1997 data. Data from 1998 is not yet available). Mercury levels in bottom-feeding or top predatory fish from these sites are similar to levels in fish from the Delta or Cache Creek, where consumption advisories exist. Currently, however, not enough fish tissue information has been gathered to warrant issuance of additional consumption advisories.

Ecosystem concerns with mercury may involve adverse effects on fish eating birds, mammals, and other wildlife. The Regional Board has used a 1973 National Academy of Science (NAS) guideline value of 0.5 ppm mercury in tissue (wet weight) to define mercury concentrations of ecological concern in the Central Valley. The use of the NAS guideline has been questioned. Guidelines have been proposed by several other institutions. Determination of mercury levels which will adequately protect wildlife communities is currently an area of international research[1].

For PCBs and chlorinated pesticides, the primary concern to date has been for ecological effects on fish and wildlife. Documented effects, though not studied in the Central Valley, include impairment of reproduction, nervous system and immune system function. High PCB levels in tissue and correlated impairment of immune system function have been found in fish-eating mammals in San Francisco Bay. The 1973 NAS guidelines for these chemicals have been used to define concentrations of concern.

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[1] Criteria exist for concentration of mercury in the water column. The USEPA recommended criterion for protection of freshwater aquatic life from chronic effects of mercury is 0.012 μg/L (recommended average of concentrations measured on four consecutive days). In December, 1998, the California Office of Environmental Health Hazard Assessment published draft public health goals for chemicals in drinking water. These proposed levels are expected to be protective of humans drinking water over a lifetime. The proposed public health goal for mercury is 1.2 μg/L.

There are two difficulties associated with determining possible adverse effects by measuring mercury in the water column. First, concentrations in tissue of large, predatory fish species may be 10,000 - 1,000,000 times greater than in the water column. Concern arises over mercury consumed by organisms at the top of the food web (including humans eating large fish species), not by direct toxicity of mercury in the water column. Predicting fish tissue mercury levels from water measurements results in high levels of uncertainty. USEPA has committed to releasing water quality standards that factor in biomagnification in three to five years. Second, the water column criteria listed above are for total recoverable mercury in water samples, which in most cases contain mainly inorganic mercury. The primary form of mercury that biomagnifies is methyl mercury. Quantification of methyl mercury requires ultra-clean techniques for sample collection and analysis and is expensive.

Sources

Mercury sources are both naturally occurring and introduced by human activities. Sources include natural deposits, discharges from historic mining sites, releases from contaminated sediments, atmospheric inputs, and point sources (e.g. municipal wastewater treatment plant discharges, industrial discharges). The relative magnitude of some sources is not known; on the other hand, reliable data for some sources (e.g. municipal treatment plants) indicates that these sources are relatively insignificant compared to the total quantities transported in the Sacramento River.

Sources of PCBs, chlordane, toxaphene, and DDT are the result of past or present human activities. PCBs have been used extensively in electrical transformers and other electrical devices. Leakage and disposal of PCBs in the environment has resulted in contamination in urban areas. The chlorinated pesticides were used extensively in urban and agricultural settings, but are now banned from use in the United States. These chemicals are persistent in the environment in water and sediment. Existing sources of PCBs, chlordane, toxaphene, and DDT include contaminated soil, contaminated bottom sediments and runoff from sites of past manufacturing, use and spills.

Areal Extent of Problem

Mercury contamination exists in the Coast Range (due to natural cinnabar deposits, discharges from geothermal activity and drainage from unremediated, inactive and abandoned mercury mines) and in the Sierra Nevada Mountains (due to extensive use and distribution during the gold mining era). Deposits of mercury-contaminated sediments are present in the Delta and lower portions of the Sacramento River and major Sierra Nevada tributaries and associated reservoirs, as a legacy from hydraulic mining. Bioaccumulation problems in fish are predominantly seen at the lower elevations in the watershed: in reservoirs, in the lower main stem river and in the Bay-Delta. Problems with bioaccumulation of PCBs and chlorinated pesticides have been observed in the same general areas, albeit less extensively.

The 1998 Clean Water Act 303(d) list of impaired waterbodies contains the following waters as impaired due to levels of mercury in fish: Delta waterways, Sacramento River between Red Bluff and the Delta, Lower Feather River, Lower American River, Sacramento Slough, Clear Lake , Lake Berryessa, Cache Creek and tributaries, and Davis Creek Reservoir. These listings are based on a data set collected between 1978 and 1993.

The 1998 Clean Water Act 303(d) list names the Natomas East Main Drain as impaired due to levels of PCBs in fish and has listed Delta waterways, the Lower American River, the Lower Feather River and the Colusa Basin Drain as impaired due to levels of chlorinated pesticides. The data used in these listings is less extensive and should be verified with new data. Based on water and sediment concentrations, the San Francisco Bay Regional Monitoring Program has suggested that the Sacramento and San Joaquin Rivers are significant sources of DDTs to the Delta and Estuary.

Temporal Extent of Problem

Problems associated with bioaccumulation and biomagnification occur over long time periods. As a result, the problem does not vary significantly over short time intervals (weeks or months).

Stakeholders

A number of parties are affected or have interest in the problems associated with bioaccumulation. These include recreational fishermen, boaters, marina operators, tourist industries, environmental advocates, the general public, regulatory agencies, permitted dischargers, landowners, and others.

Known Data Gaps

A number of data gaps are known to exist regarding bioaccumulative chemicals in the Sacramento River watershed. These include levels in fish, levels in wildlife, quantification of sources, information about fate and transport of mercury in water and sediment, factors that control transformation of one molecular form of mercury into another, and risk assessment information. Risk assessment involves determining the potential for adverse effects on fish-eating humans, birds and other animals. For mercury in particular, knowledge is lacking about the conditions under which mercury becomes methylated and which inorganic chemical forms are most likely to become methylated. The current state of knowledge about mercury, PCBs, and other bioaccumulative chemicals of concern needs to be assessed in order to organize and prioritize these data collection activities.

More fish tissue information is needed in order for OEHHA to determine whether fish consumption advisories should be issued for additional sites in the Sacramento River Watershed. Proper protection of the public from mercury contamination requires carefully validated studies of which types of fish are likely to be consumed and which are not. Researchers would have to include persons who subsistence fish and be aware of fish consumption patterns among different ethnic groups. Such studies have not been conducted. As mentioned above, small studies suggest mercury levels in some fish species pose a risk to human consumers, especially pregnant women and children. More data is needed for fish from the Sacramento River, its major tributaries and Cache and Putah Creeks. Fish from reservoirs should also be examined, as reservoirs are known to collect mercury-laden sediment.

In an attempt to begin filling data gaps, the SRWP Monitoring Program is gathering data on levels of mercury, PCBs and chlorinated pesticides in fish tissue at 12 sites in the Sacramento River Watershed and is monitoring levels of mercury in several tributaries.

II. POTENTIAL SOLUTIONS/ACTIONS

Potential solutions to address bioaccumulation problems in the watershed are not well defined. Important sources appear to be widely distributed. The natural processes which control rates of bioaccumulation are complicated and are not sufficiently understood.

A generic list of potential control measures for these chemicals includes the following:

- Control or remediation of contaminated sediments
- Control or remediation of runoff from contaminated sites
- Control of atmospheric sources
- Control of point discharges
- Control in reservoirs or control of reservoir releases
- For organochlorine pesticides, control of soil erosion from areas in which these compounds were used extensively

Before undertaking these control measures, the need exists to assess the effectiveness of these efforts in resolving identified problems. In general, better problem definition, source data, ambient data, analytical tools and risk assessment information is needed to develop a sound strategy for corrective actions for these chemicals. Sufficient mercury may already exist in the system such that efforts to control specific sources may have little effect on mercury levels in fish.

More details about mercury in the Sacramento River Watershed and Delta, including studies needed to determine sources, transport and factors influencing transformation of various forms of inorganic mercury to methyl mercury, are presented in the CALFED Water Quality Workgroup paper on mercury (released January 1999, available from CALFED Bay Delta Program 916-657-2666) and the Bay Protection and Toxic Cleanup Program draft mercury cleanup plan (released December 1998, available from the Central Valley Regional Water Quality Control Board, 916-255-3000).

References:

Davis, T. 1998. Cache Creek Annual Status Report. Staff memorandum, Yolo County Planning and Public Works Department. Woodland, CA.

Domagalski, J. 1998. National Water Quality Assessment Program Update: Water, Sediment and Biology Monitoring. Presentation made at the SRWP Toxics Subcommittee meeting, February 1998, Sacramento, CA.

Slotton, D. G., S. M. Ayers, J. E. Reuter and C. R. Goldman. 1997. Sacramento River Watershed Mercury Control Planning Project - UC Davis Biotic Component. Final Report prepared for the Sacramento Regional County Sanitation District, March 1997. Appendix B. 74 pp.

BIOACCUMULATION: ORGANOCHLORINES

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes. This is reflected in the waterbodies identified as impaired on the 303(d) list, the fact that some organochlorines are CALFED parameters of concern (chlordane, DDT, PCBs and toxaphene), and that fish consumption advisories are in effect for fish from the Bay and Delta. Also, measurements of organochlorines in fish tissue from some other areas exceed National Academy of Science guidelines to protect human health.
Important issue in Sacramento River Watershed (technical)?	Yes. Some 303(d) listed waterbodies are in the Sacramento River Watershed.
Importance to Stakeholders (perception)?	Yes. Some SRWP participants are concerned, particularly about unknown effects of these compounds acting as endocrine disruptors (also called "environmental estrogens"). Other agencies have not yet asked that the CVRWQCB focus on this as a high-priority water quality problem.
Important issue downstream?	Yes. Fish consumption advisories exist for Delta and Bay. Flow transports organochlorines in water and sediment of Sacramento River and tributaries to the Delta (some amount may deposit in sediment before reaching the Delta). It is thought that a significant source of PCBs in the Bay and Delta is recycling from contaminated sediment that is already in the Bay and Delta.
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	Yes.
Have ability to make progress on issue?	Unknown. It may be possible to control "new" amounts of organochlorines entering the main rivers and the Delta by reducing soil erosion. It would be extremely difficult and costly to remove or remediate contaminated sediment from bottom of the Bay, Delta, or rivers.
Ongoing activities by others (cooperation or leverage possibilities)	Several groups are continuing to monitor: Toxic Substances Monitoring Program (few sites within Sacramento River Watershed), SFB Regional Monitoring Program (few sites within Sacramento River Watershed), USGS NAWQA program. Some NPDES dischargers also required to monitor. No known possibilities for coordination on remediation.
Have expertise within group to move forward on issue?	There is expertise within the SRWP Monitoring Subcommittee.

Are there regulatory considerations that encourage us to work on this issue now?	Regulatory concerns include: waterbodies on the 303(d) list; fish consumption advisories in the Bay; and the fact that maximum organochlorine and PCBs levels in proposed Calif. Toxics Rule are lower than current criteria .
Adequately being addressed by others?	No.

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting.

BIOACCUMULATION: MERCURY

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes. Record of known adverse impacts includes: There are waterbodies on the 303(d) list impaired by mercury. Mercury is a CALFED parameter of concern Fish consumption advisories exist for the Bay and Delta, Measurements in fish tissue from some waterbodies not on 303(d) list exceed Natl. Academy of Science guidelines to protect human health. The entire Bay and Delta are candidate toxic hot spots under the Bay Protection and Toxic Cleanup program, due to human health threats from mercury.
Important issue in Sacramento River Watershed (technical)?	Yes. Some 303(d) listed waterbodies are in the Sacramento River Watershed.
Importance to Stakeholders (perception)?	Yes. Cache Creek Watershed Stakeholders group is actively examining mercury impacts and control strategies. Some Sierra and east-side foothill watershed groups are or are becoming concerned about the mercury issue.
Important issue downstream?	Yes. The Sacramento River Watershed is a significant source of new mercury entering the Delta and Bay yearly.
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	Yes.
Have ability to make progress on issue?	We can make significant progress in terms of providing data for fish consumption advisories to protect human health. We could likely make significant progress in controlling erosion into streams and decreasing mercury entering Sierra streams, perhaps by a mercury recovery program. Our ability to influence abandoned mercury mine remediation is questionable, because of potential liabilities.
Ongoing activities by others (cooperation or leverage possibilities)	Groups with activities include: Cache Creek Watershed Stakeholders Group; SF Bay Regional Board (they are defining the mercury problem in northern reaches of SF Bay and designing possible control programs); CALFED (may move forward on liability issue, and the Water Quality Technical Group is examining the mercury issue); CVRWQCB (recently released draft cleanup plan); USGS; and USFWS.

Have expertise within group to move forward on issue?	Yes. It would be most useful for SRWP to join with existing groups working on the mercury problem.
Are there regulatory considerations that encourage us to work on this issue now?	Regulatory concerns include: waterbodies on the 303(d) list; concentrations of mercury in water samples from Sacramento River and tributaries that exceed current Water Quality Criteria; Bay Protection and Toxic Cleanup Program toxic hot spot list; OEHHA fish consumption advisories. Also, US Fish and Wildlife Service has issued a Biological Opinion in response to the proposed CA Toxics Rule objective for mercury, stating that the proposed objective is too high and that mercury impacts beneficial uses at concentrations currently seen in the environment.
Adequately being addressed by others?	No.

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting

Water Quality Management Issue: Drinking Water Quality

Kathy Russick, Sacramento Stormwater Management Program (County of Sacramento)
Elaine Archibald, Archibald and Wallberg Consultants

Background

The Sacramento and San Joaquin River Watersheds and the Sacramento-San Joaquin Delta (Delta) provide drinking water for over two thirds of the people in California, with the Sacramento River contributing the majority of the flow. As the Sacramento River flows downstream, natural phenomena and human activities degrade its water quality including drinking water constituents of concern. Within the Delta itself, additional factors come into play impacting drinking water constituents of concern, particularly due to saltwater intrusion

I. PROBLEM STATEMENT

The drinking water constituents of concern in the Sacramento River are organic carbon, total dissolved solids, pathogens, turbidity, and nutrients. Increased levels of these constituents can require increased and more costly water treatment. More stringent drinking water regulations are anticipated at the federal and/or state levels, which would also require higher levels of water treatment.

Bromide, another drinking water constituent of concern, is a concern within the Delta but not in the Sacramento River itself.

Constituents of Concern and Sources

<u>Organic Carbon</u>
Organic carbon combines with the chemicals used to disinfect drinking water to form disinfection by-products. Many disinfection byproducts are carcinogenic and are regulated under the Safe Drinking Water Act. Organic carbon occurs naturally in surface waters. Natural organic matter has many origins including organic soils and sediments, algae growth, decaying terrestrial vegetation, riparian vegetation, and animal waste. Anthropogenic sources include wastewater and urban runoff discharges, crop vegetation, and wastes from confined and grazing animals. The relative importance of these various sources is unknown.

CALFED established a water quality target range of 2 to 4 mg/L for Delta raw water supplies but did not establish a target range for the Sacramento River. The Department of Water Resources (DWR) Municipal Water Quality Investigations (MWQI) Program has monitored the Delta and its tributaries for parameters of interest to drinking water suppliers. Dissolved organic carbon concentrations range from 1.4 to 7.7 mg/L with a median of 2.1 mg/L in the Sacramento River at Greene's Landing, downstream of the urban Sacramento area (DWR, 1996). Concentrations in the American River range from 1.4 to 4.3 mg/L with a median of 1.9 mg/L at the Fairbairn Water Treatment Plant which is located downstream of a significant portion of the Sacramento urban area (DWR, 1996).

Total Dissolved Solids

Total dissolved solids (TDS) or salinity is a critical drinking water quality issue for a number of reasons. TDS is regulated by DHS as an aesthetic standard, but high levels of TDS can have significant economic costs due to more rapid corrosion of water distribution system and structural pipes. Elevated TDS can affect wastewater reclamation programs, groundwater conjunctive use programs, and water supply blending projects.

Potential sources of TDS in the Sacramento River Basin are agricultural drainage, urban runoff, and municipal and industrial wastewater discharges. Approximately 60 to 70 percent of the load to the Sacramento River at Greene's Landing comes from unidentified sources with about 26 to 33 percent coming from the Colusa Basin Drain and Sacramento Slough (Brown and Caldwell, 1995). CALFED did not establish a water quality target for TDS in the Sacramento River. The national drinking water Secondary Maximum Contaminant Level (for aesthetic or other non-health considerations) is 500 mg/L. TDS concentrations in the Sacramento River at Greene's Landing range from 39 to 132 mg/L (Brown and Caldwell, 1995). This is considered high quality drinking water. TDS concentrations are likely to increase as the population of the Sacramento Valley increases.

Pathogens

Surface water supplies may contain a variety of microorganisms such as coliform bacteria, *Giardia*, *Cryptosporidium*, and viruses. Coliform bacteria are generally not harmful to humans but are an indicator of the general level of urban and animal contamination of a surface water. Coliform bacteria indicate that other pathogenic organisms may be present. *Giardia lamblia* and *Cryptosporidium parvum* are protozoan parasites that can exist in animal hosts and can be passed on to humans through untreated or inadequately treated drinking water. These pathogens are resistant to disinfection. There are dozens of species of enteric viruses that are known to be transmitted by water. Virus types which are of concern in drinking water are hepatitis A, Norwalk, rotoviruses, adenoviruses, enteroviruses, and reoviruses. Potential sources of pathogens in the Sacramento River watershed include urban runoff, Sacramento combined sewer discharges, wastewater discharges, wild animals, domestic animals, dairies, and other confined animal facilities.

Historically, pathogenic microorganisms were not monitored in surface waters or discharges. The EPA's Information Collection Rule requires all large utilities to monitor their raw and finished drinking water for *Giardia*, *Cryptosporidium*, and viruses monthly for 18 months[2]. The DWR MWQI Program is currently conducting a pathogen monitoring program throughout the State Water Project system. Year 1 and Year 2 monitoring plans of the Sacramento River Watershed Program include analysis for *Giardia*, *Cryptosporidium* and coliform bacteria.

In addition to pathogens affecting requirements for treatment of drinking water, pathogens are also a human health concern during contact recreation.

Turbidity

Turbidity is of concern in drinking water supplies because it can render water aesthetically unacceptable to the consumer, reduce the efficiency of disinfection by shielding microorganisms, and act as a vehicle for the concentration, transport, and release of organic and inorganic contaminants, bacteria, and viruses. Turbidity concentrations fluctuate in the Sacramento River with the highest concentrations occurring during and immediately after major storm events. Turbidity levels in the Sacramento River at Greene's Landing range from 4 to 70 NTU (DWR, 1994).

Nutrients

Nutrient levels in drinking water are typically not of themselves problematic. Rather, elevated nutrient levels can cause problems in drinking water supplies when they promote the growth of nuisance algae species and/or cause excessive algal growth. Both excessive algal growth and nuisance algae can generate taste and odor compounds that can be readily detected by consumers. Refer to "Water Quality Management Strategy: Excess Nutrients" for further discussion of nutrient-related drinking water quality problems.

Data Gaps

General sources of drinking water quality constituents are known but the proportion and nature of the contaminant loading of these sources are not well understood. Therefore, the following data collection activities are recommended to begin to understand the nature of the sources of drinking water contaminants in the Sacramento River watershed.

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[2] The 1989 USEPA Surface Water Treatment Rule requires that drinking water treatment facilities remove or inactivate 99.9% of *Giardia* and 99.99% of viruses present in raw drinking water supplies. The same Rule set maximum contaminant level goals (MCLG) of zero for *Giardia lamblia*, viruses and *Legionella* in treated drinking water, but these are non-enforceable. The 1989 USEPA Total Coliform Rule requires that no more than 5% of water samples collected after treatment test positively for total coliform (if fewer than 40 samples are collected per month, no more than one sample may test positive for coliform). The 1998 USEPA Interim Enhanced Surface Water Treatment Rule added that drinking water treatment facilities must remove or inactivate 99% of protozoa in the genus *Cryptosporidium* and set a *Cryptosporidium* MCLG of zero.

Organic Carbon

Previous studies have shown that there is insufficient information on the sources of organic carbon in the Sacramento River watershed. During Year 1 and Year 2 monitoring, the Sacramento River Watershed Program (SRWP) will collect some data on organic carbon concentrations at a number of locations along the Sacramento River and its major tributaries. Data are needed on the concentrations and loads of organic carbon in urban runoff, wastewater discharges, and agricultural drainage. The extensive monitoring program being developed by CALFED could augment the organic carbon monitoring conducted by the Sacramento River Water Program.

Total Dissolved Solids

Information is needed on the key sources of TDS in the Sacramento River watershed. CUWA is undertaking a study of the key point sources of TDS in the watershed. The SRWP includes TDS analyses in its water quality monitoring. As the population of the watershed grows, there could be a need to identify potential mitigation measures for increased wastewater and urban runoff discharges that are high in TDS. The determination of what TDS levels are needed for the Sacramento River are in the purview of the State Water Resources Control Board and Regional Water Quality Control Boards.

Pathogens

There are fairly limited data on pathogens in the Sacramento River watershed. Some data have been collected by DWR and by water agencies under the Information Collection Rule (ICR). Due to the limitations of pathogen monitoring and analytical techniques, these data may be useful in qualitatively assessing pathogen levels but not in determining if pathogen levels are a problem in the Sacramento and/or if the Sacramento River watershed is a significant source. Substantial research into better pathogen analytical methods is currently underway in the drinking water industry. It is likely that significantly improved and reliable analytical methods will be developed over the next few years.

In the near term, the SRWP should consider conducting preliminary pathogen monitoring in the Sacramento River watershed at selected sites. To best compare the pathogen results, this monitoring should follow ICR protocol and include *Giardia*, *Cryptosporidium*, and enteric viruses. The results can then be compared to ICR compliance pathogen data that has been generated by water agencies for surface waters throughout the state. The monitoring results could be used in qualifying pathogen levels throughout the watershed.

Turbidity

Since turbidity is a common water quality parameter, substantial data exists on turbidity levels along the Sacramento River and the general causes of turbidity are known. Turbidity increases can be caused by the direct input of particulate matter into water from stormwater runoff, construction, agriculture, grazing animals located near waterways, confined animal facilities, channel dredging, and erosion of river banks by boating. Turbidity increases can also be caused indirectly by nutrient inputs into the river which then cause algal blooms. Significant nutrient inputs include sediment laden with nutrients, grazing animals, industrial and municipal wastewater discharges, fertilizers applied to agriculture, and urban runoff.

Fluctuations in turbidity due to storm events are expected in the Sacramento River and are acceptable to the drinking water industry. Of concern are increases in turbidity due to human activities, either through excessive erosion or through extensive nutrient input which leads to algal blooms.

To evaluate the nature of turbidity within the Sacramento River, consideration should be given to gathering historic turbidity, river flows, nutrient, algae, and chlorophyll data along the Sacramento River. This data should be mapped along the river and evaluated for historic trends. Specifically, overall changes in average turbidity levels should be looked for as well as overall changes in peak turbidity levels. The ultimate goal would be to link any overall increases in turbidity levels with changes in land uses within the watershed. An evaluation of turbidity levels along the Sacramento River should be performed in conjunction with an evaluation of nutrient inputs along the river.

DRINKING WATER

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes. Organic Carbon - can increase disinfection byproducts when raw water is treated for drinking use. Currently not a problem in the Sacramento River Watershed; is a potential problem in the Delta. Total Dissolved Solids - has potential to impact downstream uses of Sacramento River water to dilute saltier water. Not currently a problem in Sacramento River Watershed. Pathogens - have potential to impact domestic water supplies and recreation throughout the Watershed. Current disinfection efforts in Watershed and Delta are satisfactory. Turbidity - can affect treatment efficiency and cost multiple ways. Currently not a problem in Sacramento River Watershed; has potential to impact users of mainstem river and Delta water. Nutrients - Excess nutrients currently causes algal blooms in reservoirs that draw water from Delta. Proportion of nutrients originating in Sacramento River Watershed is unknown.
Important issue in Sacramento River Watershed (technical)?	Various drinking water constituents may become issues with changing land use. As population grows, Sacramento River Watershed might be impacted in the future.
Importance to Stakeholders (perception)?	Probably most stakeholders concerned over drinking water issues reside in the Delta or further downstream. Some stakeholders have expressed concern about risks of pathogen infection during contact recreation in Sacramento River, tributaries and reservoirs.
Important issue downstream?	Yes - Sacramento River is a major source of fresh water to Delta. Total dissolved solids, turbidity, pathogens and excess nutrients are CALFED water quality paratmeters of concern.
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	There is enough of a concern on gathering more information, but not on developing control strategies. Definitely an issue to CALFED.
Have ability to make progress on issue?	SRWP has the ability to fill data gaps. We should wait until improvements have been made and verifed in the analytical methods for measuring pathogens, before conducting extensive pathogen monitoring studies.
Ongoing activities by others (cooperation or leverage possibilities)	CALFED (monitoring and implementation plan), MWQI (monitoring), DWR-(monitoring in aqueduct), We should address management only, not sure how effective to interact w/ CALFED.

Have expertise within group to move forward on issue?	The SRWP Toxics Subcommittee needs participation by Dept. Water Resources drinking water experts. We would like assistance from drinking water purveyors in evaluating data SRWP collects.
Are there regulatory considerations that encourage us to work on this issue now?	USEPA and Calif. Dept. Health Services have issued criteria for some constituents and pathogens. Stricter federal and state standards for all constituents of concern are expected.
Adequately being addressed by others?	No, SRWP is only program operating in the Sacramento River Watershed that is gathering ambient data (Ambient refers to samples taken in the river or stream at sites not directly associated with any drinking water intake).

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting.

Water Quality Management Issue: Excess Nutrients

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I. PROBLEM STATEMENT

The excessive fertilization of waterbodies is a common cause of readily discernible water quality impacts. Overabundant plant and subsequent bacterial growth depletes dissolved oxygen, which then impacts fish and invertebrate survival. The excessive growth of aquatic plants (algae and water weeds) is causing impaired water quality in some parts of the Sacramento River Watershed, especially the Pit River above Lake Shasta, Clear Lake, and the American River; within the Sacramento - San Joaquin River Delta; and in water supply reservoirs that utilize Delta waters as a source of supply. Specific problems include impaired use of water in Sacramento River tributaries in the northern watershed, occasional taste and odor problems in the City of Sacramento domestic water supply taken from the American River, and interference with recreational activities and increased pump maintenance due to excessive growth of attached algae and floating water weeds (water hyacinths) in the Delta. Of particular concern to water utilities that export Delta water is the excessive growth of algae in water supply reservoirs that use Delta waters which lead to severe taste and odor problems, shortened filter runs and increased trihalomethane (THM) precursors which lead to increased chloroform and other potential carcinogens in treated water supplies.

Cause of the Problem

Excessive fertilization of waterbodies by nitrogen and phosphorus compounds can lead to severe water quality deterioration. The chemicals of greatest concern are nitrate, nitrite and ammonia, and to a lesser extent, organic nitrogen. Soluble orthophosphate is the form of phosphorus that is readily usable by algae. Particulate phosphate, such as that associated with erosion, is largely unavailable to support algal growth. Sources of excess nutrients include domestic wastewater additions to the Sacramento River and its tributaries, as well as runoff from cultivated agriculture and dairies.

From the information available, the growth of algae and other aquatic plants in the Sacramento River system and Delta is primarily controlled by the rate of addition of nitrate and ammonia to these waters from land runoff/drainage and wastewater discharges. At times, the concentrations of nitrogen compounds available to algae are growth-rate limiting. This typically occurs during late summer at peak summer algal biomass. Generally, there is a large (10 fold) excess of soluble orthophosphate compared to the algal available nitrogen present during peak biomass during the late summer which indicates that phosphorus is not limiting algal growth and that it may be hard to control phosphorus inputs sufficiently to make it limiting. While phosphorus does not appear to be limiting aquatic plant growth, its addition to the Sacramento River system above normal background levels is a key element in contributing to the excessive fertilization of these waters.

There are no single-value nutrient water quality criteria or standards that identify nitrate or phosphate concentrations, above which excessive fertility-induced water quality problems are produced. The impact from nitrogen and/or phosphorus on aquatic plant-related water quality problems depends on a variety of factors such as the concentrations of available forms of nutrients; sunlight duration, intensity and penetration; the morphological and hydrological characteristics of the waterbody; etc. While light limitation is always a factor governing phytoplankton growth rates, from the information available , the Secchi depth data has indicated that at times the light transparency of the Delta waters is such that the rate of growth of phytoplankton is severely light-limited.

The lower parts of the Sacramento River near Sacramento are not experiencing excessive algae and other aquatic plant growth which could cause significant impairment to recreational use of these waters or to domestic water supply problems. The ability of rivers, such as the Sacramento River, to absorb high nutrient loads without significant problems is related to the turbulence of the river which prevents algae from growing to maximum biomass and accumulating near the surface of the water as floating scum. However, domestic water supplies that use fertile river water as a raw water supply often experience algal taste and odors. The City of Sacramento water utility that uses American River water as a raw water supply occasionally experiences algal related water quality problems such as taste and odors[3].

While not a problem of the Sacramento River system, some areas in the eastern reaches of the Delta near Stockton in the San Joaquin River system are experiencing excessive algal growth. Limited water exchange in these areas leads to nuisance growths of blue-green algae and low dissolved oxygen conditions.

Impacts of Nutrients on Aquatic Ecosystems

The introduction of aquatic plant nutrients to a waterbody, in addition to stimulating the excessive growth of algae, also stimulates fish production. There is a direct relationship between nutrient loads to waterbodies and fish biomass (Lee and Jones, 1991). However, with increasing fertility, especially at high levels, the types of fish that develop tend to be less desirable, such as

[3] Taste and odor problems originate from compounds in the water column, such as geosmin, that are by-products of algal metabolism. A probable source of these compounds in the American River is from attached algae growth on rocks in the river. The American River, unlike the Sacramento River, is usually quite clear, which facilitates attached algal growth. Taste and odor problems are most likely to occur when American River temperatures are at their peak, generally in August - October. The City of Sacramento currently does not normally treat drinking water for algal-related taste and odor problems. However, there have been a few times over the past 18 years whcn such treatment was needed. Treatment for algal-related taste and odor problems is difficult and can be expensive. Treatment during a problem period by activated carbon at the Fairbairn Water Treatment Plant, which draws from the American River, is estimated to cost $10,000 per day. (personal communication from R. Meyers of Fairbairn Water Treatment Plant to J. Cooke)

carp. From a fisheries resource manager perspective, the Delta is characterized as having insufficient primary production (algal growth) to support the desired fish populations. This appears to be related to two factors. First, the short residence time of the water within the Delta before it either leaves the Delta through pumping or through discharge to San Francisco Bay precludes the development of maximum algal growth based on the nutrients available. However, when Delta waters are allowed to stand in water supply reservoirs for extended periods of time, excessive algal growths occur in these waters.

Another factor that appears to be limiting algal growth within the Delta is the reduced light penetration associated with the discharge of Delta island agricultural return waters to Delta channels. The high total organic carbon and its associated color derived from farming of peat soils causes reduced light penetration which slows the rate of algal growth. This may be one of the reasons why the water hyacinths do well in the Delta since they float on the surface.

One of the often ignored impacts of aquatic plant nutrients on water quality is their impact on sediment toxicity to some forms of aquatic life. Several studies have shown that the primary cause of aquatic sediment toxicity is low dissolved oxygen (DO), and the resultant development of toxic concentrations of ammonia and hydrogen sulfide. For most waterbodies the primary cause of low DO in sediments is the biological oxygen demand of algae that become part of the aquatic sediments. The algal biomass that causes the sediment DO depletions are usually controlled by the algal nitrogen and phosphorus input to the waterbody. While most sediment-based water quality management programs focus on heavy metals and selected organics, aquatic plant nutrients are a far more important cause of aquatic life toxicity than these chemicals (Lee and Jones-Lee, 1996).

Data Gaps

At this time, there is a poor understanding of the sources of nitrogen and phosphorus compounds for the Sacramento River system and Delta and the relationship between current nutrient loads and the water quality use impairments associated with excessive growths of algae and other aquatic plants in these waters. This is an area that needs attention in order to formulate technically valid, cost-effective nutrient control programs to manage the excessive fertilization of the Sacramento River and its tributaries, and the Delta and its tributaries.

The relationship between nitrogen and phosphorus loads to the Delta and the desirable aquatic resources within the Delta, such as fish populations, is poorly understood. It could be that substantial changes in nutrient loads would have little or no impact on fish and other desirable forms of aquatic life populations. On the other hand, significantly reducing the nutrient loads to the Delta would be in the direction of improving domestic water supply raw water quality for the water utilities that use Delta waters as a source.

II. POTENTIAL SOLUTIONS

There is need to quantify the magnitude, extent and duration of excessive fertilization problems within the Sacramento River system, Delta and in downstream reservoirs used for water supply purposes. Within the Delta there is need to initiate a monitoring program on the areal extent of water hyacinth and excessive attached algal growth which impair recreational uses of the Delta. For domestic water supply problems, the frequency and severity of tastes and odors and other problems and the costs associated with their control should be compiled. This information would provide insight into the magnitude of the excessive fertility of the Sacramento River system and Delta waters to the use of these waters for domestic water supply purposes.

An assessment of algal available nitrogen and phosphorus loads to various parts of the Sacramento River watershed and the Delta should be undertaken. Further, the factors controlling excessive growths of algae and water hyacinths within those parts of the Sacramento River watershed and Delta that are experiencing excessive aquatic plant growth should be examined. The ultimate goal of this effort is to develop a nutrient load - excessive fertilization water quality response relationship that can be used to begin to predict the impacts of altering nutrient loads on the water quality problems caused by excessive fertility.

Based on an understanding of algal available nutrient loads and their impacts on water quality, it would be possible to assess the potential benefits in reduced water quality deterioration, as well as the detriments to increased fish production associated with controlling nutrient loads from various sources within the Sacramento and San Joaquin River systems and the Delta to various degrees. A review should be conducted to determine the potential benefits of applying techniques that are being used in other areas of the United States and in other countries to the Sacramento River watershed and Delta.

In August 1998, the US EPA announced a national strategy for development of water quality criteria for nutrients. The goals of this strategy are for US EPA to establish waterbody-specific, numeric nutrient criteria by the Year 2000 and for states and tribes to adopt recommended criteria as water quality standards by December, 2003. Staff from US EPA Region 9, State Water Resources Control Board, Regional Water Quality Control Boards and others are currently developing criteria for the Sacramento River Watershed.

Suggested Approach

Because of the importance of nutrient-related water quality problems within the Sacramento River Watershed and Delta for water utilities using American River and Delta waters as a raw water supply, the characteristics and significance nutrient-related water quality problems within the Sacramento River and the Delta watersheds, Delta and downstream of the Delta need to be examined. Further, the Sacramento River Watershed Toxics and Monitoring Subcommittees should appoint a technical review panel that would conduct a critical review of the existing information on nutrient-related water quality problems within the various parts of the

Sacramento River watershed as well as downstream within the Delta. The Sacramento River Watershed Program should include review of the impacts of the nutrients present in the Sacramento River as it enters the Delta since this will become a key issue in justifying any nutrient control programs from Sacramento River watershed sources.

Selection of the CALFED Preferred Diversion Alternative. Altered approaches for diverting Sacramento River water to central and southern California could significantly change nutrient and other pollutant loads to various parts of the Delta, San Francisco Bay and downstream water supply reservoirs. Of particular concern is the impact of altering the nutrient loads to various parts of the Delta and the Bay on eutrophication-related water quality and fisheries resources. There is an urgent need for CALFED to place as a high priority for attention the reliable preliminary assessment of the potential consequences of each of the proposed diversion alternatives on Delta water quality. This information should be available before a preferred alternative is selected.

Acknowledgment

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Several of the references to work of the authors are available from their web site, http://members.aol.com/gfredlee/gfl.htm or directly from the authors. Comment or questions on this discussion are welcome.

EXCESS NUTRIENTS

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes. The Pit River and Clear Lake are identified on the 1998 Clean Water Act as impaired due to excess nutrients. Ground water has been impacted by nitrates from septic tanks in several areas, including Paradise and Sierra Valley (at the headwaters of the Feather River).
Important issue in Sacramento River Watershed (technical)?	Yes in certain areas - Pit River, Clear Lake, affected tributaries, agricultural drains
Importance to Stakeholders (perception)?	Yes, stakeholders in localized areas of the Sacramento River Watershed have expressed concerns over excess nutrients.
Important issue downstream?	Yes. Excess nutrients in Delta waters can cause algal blooms when waters are pumped into and stored in reservoirs. Also, excess aquatic weed growth in the Delta increases pumping costs and is a nuisance to recreators. The proportion of excess nutrients entering the Delta from the Sacramento River Watershed, as opposed to other sources, is unknown. Excess nutrients is a CALFED water quality parameter of concern.
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	Yes.
Do we have ability to make progress on issue?	Steps we could achieve are: 1) define sources, using SRWP's monitoring program and data from others; 2) define the extent of the problem, also by monitoring; and 3) educate stakeholders about controlling runoff.
Ongoing activities by others (cooperation or leverage possibilities)	Several possibilities for cooperation: nutrients are a CALFED parameter of concern and CALFED will likely fund some projects; CRMP group in Lake County has received National Resource Conservation Service EQUIP grant to address erosion and stream bank protection in Clear Lake; Upper Pit River Watershed Protection and Enhancement Program has received 3199(h) and 204 grants, in part to work on nutrient issue.
Have expertise within group to move forward on issue?	Yes.

Are there regulatory considerations that encourage us to work on this issue now?	There are several waterbodies on the 1998 303(d) list as impaired due to nutrients. Also, nutrients criteria are expected to be issued by USEPA.
Adequately being addressed by others?	No.

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting.

Water Quality Management Issue: Metals

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I. PROBLEM STATEMENT

For the purposes of this discussion, "metals" are defined to include the following common trace elements: arsenic, cadmium, copper, chromium, lead, nickel, selenium, silver, and zinc. In the aquatic environment, these metals exist in the water column, in the sediments, and in biota. Metals move between these compartments in response to a variety of chemical, physical and biological processes, including adsorption to and desorption from particles, sedimentation and resuspension, chemical reactions, biological uptake and decay.

The primary concern with trace metals addressed in this paper is toxicity to aquatic organisms. Toxicity varies depending on the chemical form of the metal, the environmental compartment in which it resides, the exposure and availability to organisms, and the concentration at which it is present. Problems may result from excessive concentrations of metals in water, sediment, and tissue. These problems may include adverse effects on reproduction, development or survival of organisms.

Metals impacts associated with accumulation in biota are not addressed herein but are addressed in a separate issue paper dealing with bioaccumulative substances. Mercury, which is not problematic due to aquatic life toxicity in the watershed but is of concern due to levels in fish, is addressed in that separate issue paper.

Type of Problem

The metals problems addressed in this paper are ecosystem concerns. Ecosystem concerns with metals include (1) adverse effects on aquatic organisms which are important components of the food chain and (2) direct effects on larger aquatic species, including fish and amphibians.

Metals toxicity depends on the bioavailability of specific metal forms. For instance, a metal which is tightly bound to a particle or is buried in deep sediments will not contribute to aquatic life toxicity in a significant way. On the other hand, free metal ions in the water column are readily bioavailable and are the most toxic form of most metals.

EPA has recommended that dissolved metals measurements be used to judge water column toxicity of metals. Regional Board Basin Plan metals objectives for protection of aquatic life are expressed as dissolved. The Regional Board uses Basin Plan objectives, EPA National Toxics

Rule standards, EPA aquatic life criteria, and other numerical guidelines to define water column concentrations of ecological concern in the Sacramento Valley.

Sources

Metals sources are both naturally occurring and introduced by human activities. Sources include natural deposits, discharges from historic mining sites, releases from contaminated sediments, atmospheric inputs, urban and agricultural runoff, and point sources (e.g. municipal treatment plant discharges, industrial discharges). The relative magnitude of some sources is not well documented; on the other hand, reliable data for some sources (e.g. municipal treatment plants) indicate that these sources are relatively insignificant compared to the total quantities transported in the Sacramento River.

Different sources produce different forms of metals. Metals in urban storm or erosion-related runoff tend to be largely associated with soil particles due to the higher sediment concentrations in these discharges. Metals in acid mine drainage are dissolved as they released, but a large proportion quickly precipitates as the drainage enters a larger waterway. Metals in treatment plant discharges also have a fairly high dissolved fraction, since treatment processes typically remove particles. It is important to understand the forms that metals take after discharge and as they move downstream, because chemical equilibrium processes alter the nature and fate of metals in the natural environment. Some research has been done on metal forms occurring in specific areas, such data collected in Lake Shasta and Keswick Reservoir as part of mine drainage assessments.

Metals associated with acid mine drainage differ, depending upon ores present at each site. Metals of concern in stormwater runoff from industrial and urban areas likely include cadmium, copper, lead and zinc (source: Sacramento Stormwater Management Program). Copper and, to a lesser extent, zinc, compounds are used in a wide variety of pesticide applications in the Sacramento Basin. A recent USGS study found lead from the Shasta Mining district area comprises a small portion of the lead loads in the Sacramento River downstream of Bend Bridge, and concludes significant sources of lead exist below the City of Redding (Alpers, 1998). The USGS study also approximated agriculture runoff contributes about 20% of the load of copper flowing past Freeport in the Sacramento River during the irrigation months of May and June (Alpers, 1998).

Areal Extent of Problem

Metals have been observed at levels of concern in streams draining abandoned mine sites, in Keswick Reservoir, and in the Sacramento River between Keswick Reservoir and Red Bluff. Adverse effects on aquatic life, including fish kills (rare since remediation has begun), absence of other aquatic species and toxicity of water and metal-enriched sediment to bioassay organisms, have been documented in creeks impacted by acid mine drainage above Keswick Reservoir.

Metals impacts have occurred in the upper main stem based on measured concentrations in water and sediment.

Data collected by the USGS, Sacramento Coordinated Monitoring Program, and the Regional Board indicate that dissolved metals concentrations in the Sacramento River and major tributaries downstream of Red Bluff do not exceed metals objectives or criteria (Alpers, 1998; Clark, 1998; LWA, 1996 a & b). The Regional Board data included over 500 water samples collected from the lower mainstem Sacramento River, San Joaquin River and Delta in wet and dry periods. In contrast, Goetzel and Stephenson (1993) found water quality objectives were exceeded in samples from the lower American River (for lead), the Sacramento River at Elkhorn (for chromium, copper and lead) and downstream of several foothill reservoirs. Elevated levels of dissolved metals have also been measured in Spring Creek, Keswick Reservoir, and other locations in the upper watershed, as noted below.

Nickel in water samples collected from the Sacramento River above Lake Shasta has repeatedly caused toxicity to *Ceriodaphnia dubia*, an invertebrate test organism. These samples were collected through the SRWP in 1997-98 and by the Regional Board prior to that. Source of the nickel is unknown.

The 1998 303(d) List adopted by USEPA as part of the Clean Water Act identifies the following waterbodies as impaired due to levels of metals in water or sediment. The source of metals in all of these listed waterbodies is acid mine drainage from abandoned mines.

Sacramento River, from Shasta to Red Bluff	cadmium, copper, zinc
Keswick Reservoir	cadmium, copper, zinc
Lake Shasta	cadmium, copper, zinc
Dolly Creek (trib. to Little Grizzly Creek)	copper, zinc
Horse Creek (trib. to Lake Shasta)	cadmium, copper, zinc, lead
Humbug Creek (trib. to Yuba River)	copper, zinc
James Creek (trib. to Lake Berryessa)	nickel
Kanaka Creek (trib. to Yuba River)	arsenic
Little Backbone Creek (trib. to Lake Shasta)	cadmium, copper, zinc
Little Cow Creek (trib. to Cow Creek and Sacramento River)	cadmium, copper, zinc
Little Grizzly Creek (trib. to North Fork Feather River)	copper, zinc
Spring Creek (trib. to Keswick Reservoir)	cadmium, copper, zinc
Town Creek (trib. to Lake Shasta)	cadmium, copper, zinc, lead
West Squaw Creek (trib. to Lake Shasta)	cadmium, copper, zinc, lead
Willow Creek (trib. to Whiskeytown Reservoir)	copper, zinc

Metals have been listed by the San Francisco Regional Board as causes for impairment of Bay waters. The Sacramento River is considered to be a contributor to these metals problems in the

Bay. Metals of concern in the Bay due to potential aquatic life impairment include copper, nickel, and selenium.

Temporal Extent of Problem

Metals toxicity to aquatic life may occur over relatively short time periods (i.e. hours or days) if concentrations are sufficiently high. In small creeks where metals levels are high due to ongoing discharges or releases from contaminated sediments, metals toxicity may be persistent and ongoing. In downstream lakes and major tributaries to the Sacramento River, toxicity, if it occurs, is intermittent, reflective of high flow events or natural processes in lakes which result in elevated metals concentrations. Most of the metals transport in the watershed occurs during high flow events which create mine drainage and surface runoff and which carry major sediment loads.

Stakeholders and Interested Parties

A number of parties are affected or have interest in the problems associated with metals toxicity. These include recreational fishermen, boaters, marina operators, tourist industries, environmental advocates, the general public, regulatory agencies, mining interests, permitted dischargers, landowners, natural resources trustees and others.

Chromium VI

(this information was prepared for a separate report by G. Fred Lee. It was included here because of the potential for chromium to become an important water quality concern, as more information is gathered about its effects).

Chromium exists in aquatic systems in two oxidation states (chromium VI and chromium III). While chromium III has a low toxicity to aquatic life, and is generally regulated based on the human health hazard associated with domestic water supplies, chromium VI is highly toxic to some forms of aquatic life, especially zooplankton. Environment Canada (1994) reported that chromium VI concentrations of 0.5 μg/L were toxic to some forms of zooplankton. The US EPA (1995) presented data that showed that chromium VI was toxic to certain forms of zooplankton at about 1 μg/L. While it appears that higher levels of chromium VI are not chronically toxic to fish, there is substantial evidence that it is toxic to common forms of zooplankton (daphnids), which are key larval fish food.

A recent Central Valley Regional Water Quality Control Board staff report (Clark, 1998), presents findings of dissolved chromium in the Sacramento River and Delta at concentrations above 0.5 μg/L, i.e. those that have been found to be toxic to certain forms of zooplankton. Goetzl and Stephenson (1993) found dissolved chromium above 0.5 μg/L in over half of samples from the upper Sacramento River and tributaries to Shasta Dam, occasionally in samples from Sacramento River below Keswick and the Feather, Yuba and Bear Rivers, and in approximately one third of Sacramento River samples downstream of Elkhorn. While neither study specifically measured chromium VI, it is likely, based on the aqueous environmental chemistry of chromium, that a significant part of the measured dissolved chromium was in a chromium VI form. There is, therefore, concern about whether the measured chromium VI in the Sacramento River is toxic to zooplankton.

Some areas of the west side of the Sacramento River Watershed contain elevated concentrations of naturally occurring chromium in soil or groundwater. Chromium in groundwater enters surface water when groundwater is pumped for agricultural and domestic use.

Known Data Gaps

A number of data gaps are known to exist regarding our information about metals. These include: quantification of specific sources; additional information on fate, transport and toxicity of metals; transformation/speciation information; effects of biomagnification of metals up the food web, especially for cadmium and chromium; adverse impacts of metals in sediment; and risk assessment information. Waterbodies listed above are already known to be impacted by metals in acid mine drainage. Monitoring data from the Sacramento River Watershed Program, CVRWQCB, USGS, DWR, local tributary groups and other efforts should be evaluated to determine additional waterbodies in which metals are impairing beneficial uses. Data collection activities receiving highest priority should be for those waterbodies in which particular metals are causing impairment.

Specific information gaps identified in the 1998 Metals Transport Study Draft Implementation Plan (SRCSD, 1998) are:

- Identify sources of copper entering the Sacramento River between Keswick Dam and the City of Colusa
- Determine the fate of copper used in agriculture
- Determine sources and "hot spots" of copper in urban runoff
- Determine range and magnitude of toxicity due to cadmium, which was found to be bioaccumulated by insect larvae in the Sacramento River
- Determine sources of lead entering the Sacramento River between Bend Bridge and City of Colusa
- Determine sources of nickel in the Sacramento River above Lake Shasta, associated with aquatic toxicity

Chromium VI

A comprehensive review is needed that would determine whether chromium VI is present at concentrations in the Sacramento River Watershed and Delta that are potentially toxic to aquatic life, as well as determining whether part of the zooplankton toxicity that is found, for which the source is currently unknown, may be due to chromium VI toxicity. The studies that need to be done include collection of water from the Sacramento River Watershed and Delta to determine the actual chromium VI concentrations in these waters. At the same time, toxicity testing using *Ceriodaphnia* and *Daphnia* should be conducted. Careful consideration would need to be given as to whether the toxicity investigation evaluation (TIEs) procedures that are now used to determine causes of unknown toxicity, can properly identify chromium VI if it causes toxicity to the test organisms used.

II. POTENTIAL SOLUTIONS / CORRECTIVE ACTIONS

Potential solutions to address metals problems in the upper watershed are defined for some sources. Significant resources have been allocated to the control of mine drainage. An extensive monitoring program will continue and further remediation is planned for the abandoned mine on Iron Mountain[4]. Other abandoned mine sites are also undergoing or have remediation anticipated. Cost-effective efforts to control these sources should be continued.

A generic list of potential control measures for metals includes the following:

- Control or remediation of acid mine drainage
- Control or remediation of contaminated sediments
- Control or remediation of runoff and erosion
- Control of reservoir releases (e.g. flow management)

The need exists to assess the effectiveness of other control measures in resolving identified problems. In general, better problem definition, source data, ambient data, analytical tools and risk assessment information is needed to develop a sound strategy for corrective actions for these chemicals.

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METALS

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes. Waterbodies are listed as impaired on the 1998 303(d) list due to acid mine drainage. San Francisco Bay Regional Monitoring Program found toxicity of sediment collected from the Sacramento River near Antioch is in part due to copper.
Important issue in Sacramento River Watershed (technical)?	Yes. Metals impact the upper Sacramento River Watershed, including downstream of Lake Shasta and other tributaries on the 303(d) list. Particular metals of concern are: cadmium, copper, zinc and arsenic and possibly chromium impacting aquatic life in the stretches of the Sacramento River and tributaries, and potentially nickel impacting aquatic life in the Sacramento River above Lake Shasta. Also, use of copper as a pesticide in agriculture and for aquatic weed control is increasing.
Importance to Stakeholders (perception)?	Yes. Issues of stakeholders are similar to those listed above. The perception of metals as a water quality problem varies, depending on where stakeholders reside.
Important issue downstream?	Yes. The San Francisco Regional Board's Basin Plan identifies the Sacramento River as a primary source of copper in the Bay. Cadmium, copper and zinc are CALFED parameters of concern in the Bay-Delta.
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	Yes, at least for problems relating to abandoned mine remediation. Impairments by particular metals at other sites within the Sacramento River Watershed need to be identified.
Have ability to make progress on issue?	Yes, in part. Sources can be identified through monitoring. Implementing control strategies at some sites will depend on passage of "Good Samaritan" legislation, which would allow groups to clean up sites without possibly becoming liable for metals impacts.
Ongoing activities by others (cooperation or leverage possibilities)	USGS and SFB Regional Monitoring Program are monitoring metals at selected sites. Other clean-up efforts include: abandoned mine remediation under the USEPA Superfund program and by other institutions, and the discharge permitting process required for abandoned and active mines.
Have expertise within group to move forward on issue?	Yes.

Are there regulatory considerations that encourage us to work on this issue now?	303d list, Central Valley Regional Board Basin Plan metals objectives for the upper Sacramento River Watershed and the Delta, and discharge permits on abandoned mines
Adequately being addressed by others?	No. Iron Mountain Mine is being remediated under the federal Superfund program. Remediation at Walker and Penn Mines is being addressed by the State Water Resources Control Board and the Central Valley Regional Board.

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting.

Water Quality Management Issue: Pesticides in Surface Water Runoff

Scott Ogle, Ph.D. Pacific Eco-Risk, Inc.

I. PROBLEM STATEMENT

Over the past 10 years, there has been a growing body of evidence indicating that pesticides can be transported from agricultural lands into surface waters via stormwater and irrigation tailwater runoff at concentrations high enough to cause toxicity to non-target aquatic invertebrates. Investigations of ambient water toxicity using US EPA standardized tests have indicated a high frequency and duration of toxicity in some of these waters, and analytical chemistry and Toxicity Identification Evaluations (TIEs) have identified pesticides, particularly organophosphate (OP) insecticides, as the cause[5].

Pesticide use and toxicity associated with subsequent surface water runoff is not limited to agricultural practices. Pesticide use in urban settings for structural (i.e. termites) pest control, gardening, and even pet grooming (i.e. flea dips) can result in pesticide runoff during subsequent rainstorms (Bailey et al. 1995; BASMAA 1996). More importantly, toxicity testing of the stormwater runoff has again revealed statistically significant frequencies of toxicity to aquatic organisms (Bailey et al. 1995; BASMAA 1996; Larsen et al. 1998a). In creeks whose flow is dominated by urban runoff, toxicity due to organophosphate pesticides occurs during dry weather as well and storm events. In addition to effects from application within urban areas, urban regions in the Central Valley also experience effects of pesticides that are transported from agricultural areas by aerial drift and volatilization, and are detected in measurable and even toxic levels in rainfall (Bailey, in prep).

As the number of studies documenting ambient water toxicity to invertebrates has increased, so has the concern regarding possible adverse effects of these pesticides on important aquatic resources. There is a growing consensus that pesticides may be adversely affecting resident invertebrate populations in streams and sloughs within the watershed, which in turn may be adversely affecting fish populations which make use of these invertebrates as their main food source. While no direct link has yet been established, adverse effects of pesticides on food resources such as the invertebrates in the Sacramento-San Joaquin watersheds may play a role in the dramatic declines in fishery populations that have been observed over the past several decades, and this is clearly a potential problem that needs to be addressed.

Type of Problem and Sources

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[5] Toxicity Identification Evaluations (TIEs) follow USEPA-recommended protocols for identifying the compound(s) causing toxicity. TIEs are conducted in three phases to: 1) identify the class of compound causing toxicity, 2) identify the toxic compound within that class, and 3) confirm the toxicant. Procedures include retesting of the sample to determine if toxicity is persistent, physical manipulations and chemical separations that remove various classes or individual compounds followed by retesting to examine whether toxicity is elimnated, diluting the field sample to determine the magnitude of toxicity and chemical analysis.

Pesticides enter waterways in runoff from agricultural and urban applications and in stormwater, by direct application, and through atmospheric deposition. Herbicides entering through direct application for aquatic weed control are not discussed further in this summary.

In the Sacramento River Watershed, pesticides in agricultural runoff cause adverse effects frequently in agricultural drains and less often, but sometimes as severely, in the main rivers. Adverse effects are identified by measuring concentrations of pesticides above criteria set for the protection of aquatic life, and/or by toxicity of water samples to bioassay organisms. Toxicity to the invertebrate, *Ceriodaphnia dubia*, has been associated with runoff from dormant orchard spraying in January and February repeatedly since 1992 in agricultural sloughs and in the Feather River. This toxicity is linked to organophosphate insecticides, particularly diazinon and methidathion (Foe and Sheipline, 1993; Larsen et al, 1998a,b). On four consecutive days in January 1997, water samples collected by the UCDavis Aquatic Toxicology Laboratory from Sacramento Slough caused complete mortality to *Ceriodaphnia dubia*. Diazinon concentrations in those samples were 0.98 - 1.9 µg/L. In comparison, the California Department of Fish and Game hazard assessment criterion for protection of aquatic life from acute toxicity of diazinon is 0.08 µg/L (Larsen et al., 1998a). During storms in January and February, 1993, the DFG acute criterion for diazinon was exceeded on at least eight consecutive days in Sacramento Slough, four days in the Feather River, and five days in the Sacramento River at City of Sacramento (Holmes et al., 1998).

In the lower Sacramento Watershed and Delta, toxicity to *Ceriodaphnia* is seen during March through June and is attributable at least in part to pesticides, particularly organophosphates, from alfalfa and row crops (Foe and Sheipline, 1993; Deanovic et al. 1996). High concentrations and adverse effects from rice field insecticides, detected in the late 1980s, have largely been eliminated through altered rice cultivation methods (Bennett et al, 1998).

Pulses of diazinon in the Sacramento River during January and February in 1993 were detected moving into central San Francisco Bay, and pulse samples caused complete mortality to *Ceriodaphnia* at Rio Vista (Kuivila and Foe, 1995).

Periodic toxicity to *Selenastrum capricornutum*, a freshwater algal species used in bioassays, occurs in water samples collected from the Sacramento River during times with and without precipitation. TIEs suggest the herbicides simazine and diuron contribute to the toxicity. Other causes may be additional herbicides and fungicides that have been detected in the water.

Urban Runoff Identified as a Source of Pesticide Toxicity
In multiple stormwater runoff samples collected from Sacramento, Stockton, and several urban basins in San Francisco Bay, the OP pesticides diazinon and chlorpyrifos have been measured at toxic concentrations in over half of the samples, and toxicity tests with *Ceriodaphnia* have indicated that most of these samples have caused complete mortality of the test organisms. Upon reaching the

Bay, these waters are often still toxic, and have been shown to cause significant mortality in estuarine/marine organisms (Ogle et al., 1998). Arcade Creek, which drains mixed industrial and residential areas in north Sacramento, is toxic to bioassay organisms during rainfall and dry periods (Larsen et al., 1998a,b). TIE studies, including some using antibodies which are chemical-specific to chlorpyrifos or diazinon have identified these compounds as causes of much of the toxicity in these stormwater runoff samples (Hansen, 1994; Miller et al., 1996; Bailey et al., 1996, 1997).

Pesticide Toxicity in the Sierras
More recently, studies have indicated that aerial drift of pesticides applied in the Central Valley is resulting in deposition of these pesticides into surface waters in the Sierras at elevations as high as 2,000-3,000 ft (LeNoir et al. 1998; Fellers 1998). Studies in the Sequoia National Park revealed that numerous pesticides were found at potentially toxic concentrations, and that the tissues of aquatic organisms were exhibiting bioaccumulation of these pesticides (LeNoir et al. 1998). Studies of amphibian populations in the sierras have indicated significant declines for several frog species, and it has been hypothesized that these pesticides may be a potential cause for the declines (Fellers 1998).

Areal Extent of Problem

The 1998 303(d) List of Impaired Waterbodies, adopted by EPA as part of the Clean Water Act, considers a number of waterways in the Sacramento River Watershed as impaired because of concentrations of organophosphate pesticides in the water column. The following table, adapted from the 1998 list, shows the waterbody, the nearest major tributary into which it drains, the pesticide causing impairment and general sources.

Waterbody	tributary to:	contaminant	sources
Delta waterways		diazinon, chlorpyrifos	agriculture, urban
Arcade Creek	Sacramento River	diazinon	agriculture(aerial drift), urban
		chlorpyrifos	urban
Chicken Ranch Slough	American River	diazinon	agriculture(aerial drift), urban
		chlorpyrifos	urban
Colusa Basin Drain	Sacramento River	carbofuran, malathion methyl parathion	agriculture
Elder Creek	Sacramento River	diazinon	agriculture(aerial drift), urban
		chlorpyrifos	urban
Elk Grove Creek	Sacramento River	diazinon	agriculture(aerial drift), urban
Feather River, lower		diazinon	agriculture, urban
Morrison Creek	Sacramento River	diazinon	agriculture(aerial drift), urban
Natomas East Main Drain	Sacramento River	diazinon	agriculture(aerial drift), urban
Sacramento River (Colusa Basin Drain to Delta)		diazinon	agriculture
Sacramento Slough	Sacramento River	diazinon	agriculture, urban
Strong Ranch Slough	American River	diazinon	agriculture(aerial drift), urban
		chlorpyrifos	urban

While the information described above would seem to provide overwhelming evidence that pesticides in surface water runoff may cause toxicity to invertebrates in waters within the Sacramento-San Joaquin River basins and the San Francisco Estuary, no link has yet been conclusively established. Long-term studies of zooplankton distribution and abundance in the Sacramento-San Joaquin Delta have reported a significant decline in the number of zooplankton species in the freshwater parts of the estuary (Obrebski et al. 1992), with recent zooplankton density being 1-2 orders of magnitude lower than in the early 1970s. There has been a measurable decline in cladocerans[6] in the Delta at least since the mid 1980s (San Francisco Estuary Project, 1997). Use of OP pesticides like diazinon and chlorpyrifos has increased substantially since their introduction in the 1950s and 1960s, suggesting a possible link between pesticide toxicity and zooplankton declines. Similar adverse declines in benthic invertebrates may also have taken place over the past several decades: recent monitoring of benthic invertebrate resources in the Sacramento-San Joaquin basins by the US EPA EMAP have observed lower invertebrate abundance and diversity than expected from similar studies conducted elsewhere in the United States (P. Husby, US EPA, personal communication).

One problem in developing a consensus regarding adverse effects of pesticides in natural waters is the extension of toxicity to *Ceriodaphnia* in the lab to toxicity of resident invertebrates in the field. A recent risk assessment of diazinon in the Sacramento and San Joaquin basins concluded that while cladocerans (such as *Ceriodaphnia*) are sensitive invertebrates to OP pesticides, other important invertebrate groups, including copepods, mysids, amphipods, insects, and rotifers, are less sensitive and are likely not being affected by the existing OP pesticide concentrations (Adams, 1996). This might be a valid conclusion, if in fact the toxicity of OP pesticides to resident invertebrate species were known. Unfortunately, this is not the case. An examination of toxicity information availability for the important aquatic arthropod species in the estuary (as indicated in *Status and Trends Report on Aquatic Resources in the San Francisco Estuary*; Herbold et al., 1992) indicates that very few resident invertebrate species have any OP pesticide toxicity information available. This suggests that toxicity from these pesticides may be occurring, but the information needed to assess this does not currently exist.

Ecological Significance

It should be noted at the outset that maintaining healthy, viable invertebrate communities in our natural waters is and should be an objective in and of itself. However, it can be argued that an even more important role for these invertebrate resources is as food for priority fish populations. Numerous studies have documented that virtually all of the priority fishery populations in the Sacramento-San Joaquin River basins and the San Francisco Estuary rely upon these invertebrates, particularly during their vulnerable early life stages (Eldridge et al. 1982; Schaffter et al. 1982; Brown 1992; Moyle et al. 1992; Meng and Moyle 1996; Lott 1998; Nobriga 1998). If pulses of pesticides through these aquatic ecosystems diminish the available invertebrate resources at critical periods,

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[6] Cladocera are a suborder of small, freshwater crustaceans, commonly called water fleas. This suborder includes an organism frequently used in toxicity testing, *Ceriodaphnia dubia*.

such as when fish fry are obligately using the invertebrates for food, then adverse effects on the fish populations can be expected. This potential problem is of paramount importance as the period of high pesticide concentrations in these waters (January-June) coincides with the presence of early life stages of most of the fishery populations currently in decline. This includes delta smelt, Chinook salmon, longfin smelt, splittail, steelhead trout, and green sturgeon, all of which have been identified as "Priority Species" by the CALFED Bay-Delta program. In fact, recent studies have indicated that there is evidence of food limitation on Delta smelt (Nobriga 1998); other priority species may be similarly impacted, but have not yet been studied.

In addition to the ecological significance, pesticides in surface waters of the Sacramento River Watershed are of concern through several regulatory programs. The narrative toxicity objective of the Central Valley Water Quality Control Plan (Basin Plan) states that water shall not contain chemical constituents in concentrations that adversely affect beneficial uses, including support of aquatic life. Waterbodies identified on the 1998 303(d) list as impaired due to organophosphate pesticides are mentioned above. Several waterways are also on the 303(d) list for concentrations of historically used “Group A” organochlorine pesticides. Under the Bay Protection and Toxic Clean-up Program, the Sacramento-San Joaquin Delta is listed as a toxic hot spot due to OPs entering in agricultural and urban runoff. Finally, in the Sacramento River, tributaries and in the Delta, concentrations of chlorpyrifos on occasion exceed the Department of Fish and Game’s Hazard Assessment Criterion and the EPA’s criteria for protection of saltwater and freshwater aquatic life.

II. RESEARCH NEEDS AND POTENTIAL SOLUTIONS

The information described above clearly indicates that both agricultural and urban use of pesticides can result in concentrations in surface waters that are potentially toxic to invertebrates, depending upon the species’ sensitivities to the various pesticides. These surface waters have been shown to frequently be toxic to laboratory test invertebrates, and pesticides (in particular, the OP pesticides diazinon and chlorpyrifos) have been conclusively identified as a major cause of the observed toxicity. However, while zooplankton declines in the estuary have corresponded to increased use of these pesticides in the watershed, there is no conclusive information available to document that these pesticides are adversely impacting resident invertebrates in the watershed. Furthermore, while there have been concomitant declines in priority fish populations in the estuary, along with recent evidence indicating that some priority fish species may be suffering from food limitation at key life stages, there has yet to be a link made between potential pesticide toxicity to resident invertebrates and potential adverse affects on the fish populations that use these invertebrates as food resources.

If management and regulatory measures to restore the estuary’s ecological resources to their former level of abundance are to be effective, then the role of pesticides in the possible decline of these resources must be identified and remedied. Based upon considerable evaluation of this, several research needs have been identified and are recommended for immediate study:

Research Need #1. Determine the toxicity of key pesticides, in particular diazinon and chlorpyrifos, on invertebrate species resident to the Sacramento and San Joaquin Rivers and tributaries and in the Delta and upper San Francisco Bay.

Research Need #2. Determine the effect of these pesticides under *in situ* (i.e. "field") exposure conditions on the more sensitive invertebrates;

Research Need #3. Determine the effects of combinations of pesticides on standard laboratory test organisms and on resident species. Chemical analysis of water samples frequently shows presence of multiple compounds, but water quality criteria and risk assessments have generally been prepared for single pesticides.

Research Need #4. Conduct biological community assessment of selected field sites 'before and after' pulses of pesticides pass through, and evaluate the effects of "*in situ*" exposures on the invertebrate resources and the ability of these resources to recover from the adverse effects of pesticide toxicity.

Research Need #5. Characterize the effects, if any, of pesticide toxicity to resident invertebrates on fish populations, and in particular, the "priority" fish species.

Research Need #6. Based upon the information generated above, evaluate the effect(s) of current pesticide usage on the ecological resources of the Sacramento-San Joaquin watersheds and the San Francisco Estuary.

Potential Control Actions

Develop a list of goals and target levels for OP pesticides in the water column to protect aquatic life. The Department of Fish and Game has interim hazard assessment criteria for diazinon and chlorpyrifos, but data gaps prevent these or other proposed criteria from being adopted. Reliable water concentration targets are needed in order to plan control practices and evaluate their effectiveness.

Gather reliable monitoring data that will identify affected waterbodies and the frequency and duration of incidences of toxicity. Monitoring will also be used to determine the success of control practices.

Identify and quantify important regional sources of OP pesticides. This activity should include determining how concentrations in the Sacramento and Feather Rivers vary, depending on various load and water flow patterns.

Develop a strategic plan, that will identify management practices that will achieve the target levels. The plan may include agricultural best management practices and urban integrated pest management programs.

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ORGANOPHOSPHATE PESTICIDES (OPs) *

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes, by a number of assessments: The 1998 303(d) list identifies waterbodies in the Sacramento River Watershed and Delta impaired due to OPs. In the Feather River, Sacramento Slough and agricultural drains levels of diazinon and chlorpyrifos have exceeded Dept. Fish and Game's diazinon hazard assessment criterion and the USEPA chlorpyrifos criterion for protection of aquatic life. Diazinon concentrations in the Sacramento River have exceeded the DFG criterion. Regional Board and SRWP data show water from urban-runoff dominated creeks and urban runoff drainages is toxic to bioassay organisms, during periods with and without precipitation. The Bay Protection and Toxic Cleanup Program list of candidate Toxic Hot Spots contains the entire Delta due to diazinon and some agricultural drains due to diazinon and chlorpyrifos. Chlorpyrifos and diazinon are CALFED parameters of concern in the Delta.
Important issue in Sacramento River Watershed (technical)?	Yes, the beneficial use impacts listed above are of concern. Also, there are many sources of OP pesticides, including non-point and point sources in urban and agricultural settings, that have the possibility of being controlled. Multiple agencies are involved in assessing impacts and/or developing control strategies, including: USGS, Dept. Fish and Game, Dept. Pesticide Regulation, CVRWQCB, State Water Resources Control Board, and Sacramento Stormwater Management Program.
Importance to Stakeholders (perception)?	Yes. BayKeeper/DeltaKeeper have filed a notice of intent to sue USEPA for failing to require the State of California to establish Total Maximum Daily Loads for all waterbodies and constituents on the 303(d) list, including pesticides. A lawsuit by Sacramento River Toxics Alliance against the Regional Board resulted in a consent decree, which outlines a dormant spray pesticide control program headed by Dept. Pesticide Regulation.
Important issue downstream?	Yes. OP pesticides impact aquatic life in the Delta. Pulses of diazinon have been tracked from the Sacramento River out into the Bay.
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	Yes.

Have ability to make progress on issue?	Yes.
Ongoing activities by others (cooperation or leverage possibilities)	Activities include: CALFED, Dept. Pesticide Regulation (DPR is in Year 3 of a Dormant Spray Pesticide Program), University of California Extension, University of California Integrated Pest Management Program, Sacramento Stormwater Management Program, Urban Pesticide Committees, CURES (organization of pesticide registrants), State Water Resources Control Board water quality division, Biologically Integrated and Biorational Orchard Systems for prune, cling peach and other orchards, Agriculture Departments of Butte and Glenn Counties, a number of Resource Conservation Districts and National Resource Conservation Service. Most projects focus on aquatic monitoring or implementation of best management practices in agriculture. Some have received federal 319(h) or state 204 grants.
Have expertise within group to move forward on issue?	Yes, but the SRWP would need participation by Dept. Pesticide Regulation to make progress. (DPR has committed to developing a draft OP pesticide strategy for Phase IV of the SRWP).
Are there regulatory considerations that encourage us to work on this issue now?	Regulatory concerns include: OP pesticide-impaired waterbodies on the 303(d) list, registration, Bay Protection Toxic Cleanup Program candidate toxic hot spots in the Delta and Bay, and the fact that incidences of aquatic life toxicity violate the narrative objective of the Central Valley Regional Board's Basin Plan (water concentrations of contaminants must be below levels that cause toxicity).
Adequately being addressed by others?	No. Other projects are being conducted, but all of the water quality concerns and components of SRWP's water quality management strategies are not being addressed.

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting.
* There are other pesticides, in addition to organophosphates, that occur in urban and agricultural runoff. The Toxics Subcommittee focused on OPs because they are identified on the 303(d) list.

Water Quality Management Issue: Sedimentation

Jerry Boles, Department of Water Resources - Northern District

I. PROBLEM STATEMENT

Most stream courses naturally erode their banks, which permits sediments and gravels to deposit in the stream bed. These natural deposits form habitat for aquatic organisms. The smaller bottom sediments and gravels may be transported as suspended material while larger materials may be transported along the streambed as bedload by higher flows during the wetter portions of the year, with many of the finer materials flushed downstream. However, terrestrial activities which cause soils to be easily eroded often result in excessive levels of fine sediments to be transported to stream channels. The excessive fine sediment loads may adversely affect the stream environment.

Fine sediments can settle between gravels used for spawning by certain species of fish. These interstitial sediments can bind the gravels so that fish cannot dig redds (nests) for laying of eggs. Fine interstitial sediments can also smother eggs that have been deposited in the gravels. Interstitial sediments also decrease the flow of water through gravels, which adversely affects fish eggs and other organisms by decreasing the availability of life-sustaining oxygen, usually replenished with flowing water. Less water flow through sediments also reduces the flushing of metabolic by-products of eggs and other organisms living in the gravels, which can then build to toxic levels. A fine layer of sediments, even if only lightly coating channel gravels, can disrupt the aquatic food web by preventing attachment of algae, which is an important food source to some fish species and many aquatic insects. Sediments can also smother aquatic insects or prevent their attachment to the bottom substrate. Sediments which deposit into pools, and cause them to become more shallow, decrease habitat available for some fish species. Salmonids, in particular, depend on deeper pools to provide shelter and cooler water. Sediments deposited in stream gravels allow growth of emergent vegetation along channel margins. The constricted channel width results in increased flow in the middle portions of the channel, which alters hydrologic and habitat characteristics. Sediments also decrease channel capacity for carrying water, resulting in increased flooding at lower stream flows.

In addition to effects on aquatic organisms, sediments also impact water storage and diversion facilities. Sediments deposit in the slack water behind dams, which reduces storage capacity of these facilities. Sediments deposited near the entrance of diversion facilities reduce the capacity of canals to divert and transport water.

Type of Problem

Sedimentation is an aquatic ecosystem health concern for fish and organisms they depended on in the food web: algae and benthic invertebrates. It is also a human concern for increased flooding, decreased reservoir capacity and costs of dredging. Effects of turbidity in the water column, which is caused by suspension of very fine sediment particles, is discussed in the drinking water summary.

Types of Sources

While natural bank erosion processes in streams yield sediments and gravels, the loads are generally not adverse and contribute to aquatic habitat. Excessive loads of sediments, however, do adversely affect aquatic habitat. Such sediment loads are usually the result of soil disturbance activities. These activities include paved or gravel roads which expose soils to increased erosion from natural runoff or collect and discharge concentrated road runoff, thus increasing surface erosion in the discharge areas. Also, temporary roads used for activities such as logging can produce erosion from the road surface and exposed banks or act as pathways to concentrate runoff. Other excess sediment sources include agricultural practices which allow soils to be dislodged and carried by irrigation or winter runoff; cattle grazing which denudes soils and allow surface erosion and degradation of stream banks by cattle; and natural landslides either along or in stream channels. Forest fires which remove erosion-controlling vegetation and construction activities can also contribute to sedimentation. Many other sources of sediments occur, and include both point and non-point sources [7].

Extent of Problem

Sedimentation problems occur throughout the Sacramento River watershed, though some streams carry more sediments than others. Sedimentation is generally not site specific issue but cumulative condition in the watershed resulting from factors such as natural geology, past and/or existing management practices. While some of the sedimentation problems are naturally induced, most are due to the various activities of humans in the watersheds. Tributary watersheds above major dams (like Shasta and Oroville) may carry big sediment loads and have significant local impacts but they contribute very little sediment to the mainstream Sacramento River, due to collection of the sediment in reservoirs.

[7] A potential water quality issue related to sediment from agriculture is the treatment of irrigation water with anionic polyacrylamide (PAM) to reduce erosion on irrigated soil. PAM has been used commercially since 1995, and its popularity is growing. In the West Stanislaus Hydrologic Unit area, the US Dept. Agriculture and University of California found that PAM reduced soil loss 95-98% and increased water infiltration by 10-40%. Because nearly no soil remains suspended, nutrient and pesticide concentrations in runoff are also reduced. California currently has an interim standard for PAM use set by National Resources Conservation Service. EPA and FDA have approved anionic PAM as a soil amendment. Nearly all PAM remains on the soil to degrade. There are no reported toxicities from anionic PAM in soil, water or food products. Neutral and cationic PAMs can cause irritation to humans and aquatic toxicity, but these are not approved for agricultural use. Other potential applications for PAM are at construction sites and holding ponds. (Source: USDA web site, http://kimberly.ars.usda.gov/pampage.ssi) Regulatory approval, relatively low cost and reduction in field erosion and organic carbon and pesticide runoff could cause PAM use in the Sacramento River Watershed to increase rapidly. Impacts on aquatic organisms from widespread or long-term use of PAM or its breakdown products, however, are completely unknown. PAM use is not a current issue of concern for the Sacramento River Watershed Program, however, concern could rise with increased use in the Watershed. The CALFED Water Quality Program Plan (draft released Jan. 1999) proposes that CALFED support research into use of PAM for erosion control.

Two waterways within the Sacramento River Watershed that were specifically identified by the CALFED Water Quality Technical Group as experiencing sedimentation problems are the Upper Fall River and Humbug Creek. The Fall River is a tributary to the Pit River. It is listed as impaired on the Clean Water Act 303(d) list due to excessive sedimentation in the upper portion. Sources of sediment include forestry activities, livestock grazing, channelization of the Bear Creek meadow and roads, and streambank erosion (Tetra Tech, 1998). Management actions for stream channel and meadow restoration, stream sediment removal, erosion control best management practices, and cost estimates for these actions are provided in the Tetra Tech report. Humbug Creek flows into the Yuba River. It is a 303(d) List impaired water body due to metal and soil discharges from the abandoned Malakoff Diggins mine complex. (CALFED Water Quality Technical Group summary on sediment problems).

In the northern part of the Basin, Sacramento River tributaries with high rates of sediment discharge are: the Upper Feather River, Pit River and some westside tributaries, including Cottonwood Creek, Redbank/Reeds Creek, and Stony Creek (Heiman, 1998).

Temporal Nature

Most sediment is carried during the winter as overland flow erodes exposed soils. However, some events, such as landslides which deposit materials to stream channels, cause sediments to become carried into stream courses during dryer periods of the year. Regardless of when sediments are carried into streams, the effects are prevalent throughout the year.

Stakeholders

Those with a stake in the problems attributable to sedimentation include California Department of Water Resources, US Bureau of Reclamation, US Army Corps of Engineers, water contractors (municipal, agricultural, and industrial users), timber and cattle industries, watershed groups, CALFED, US Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Game, sport and commercial fishermen, and people living along impacted streams that experience increased flooding due to reduced flow carrying capacity.

Data Gaps

The extent of sedimentation problems in streams has not been well documented. Sedimentation problems are known in some areas as a result of studies conducted for other purposes, but sedimentation specific data are generally not collected. Though many streams are empirically known to suffer from sedimentation, the extent of sedimentation and sediment sources are generally not known.

Sediment discharge quantification is difficult because it is so episodic. As an example, in some watersheds it is likely that more sediment moved during flood conditions of January, 1997, than over the previous several years. Constant recording techniques to quantify sediment discharge and determine the contribution of various sediment sources to sediment accumulation downstream (mass balance) are in the preliminary stages of application (Heiman, 1998).

II. POTENTIAL SOLUTIONS/ACTIONS

Sources of sediments can be controlled by diverting runoff and other water flows from areas sensitive to erosion, revegetation of denuded areas, implementation of best management practices for various activities (including logging, livestock grazing and agricultural practices), and closure of roads sensitive to erosion. Watershed assessment procedures can generally identify the principal sources of sediments and guide the application of remedial measures to treat the problem.

Achieving successful education and implementation of erosion control measures involves working with local conservancies, Resource Conservation Districts, and other interested parties. Some local watershed stewardship groups are developing education and citizen volunteer programs to address problems of sedimentation[8]. Such efforts should be supported and expanded. Concerned citizens who become organized and educated about stream health assessment, sediment sources and remediation techniques, are in a unique position to evaluate local land use practices and encourage neighboring land users to adopt erosion control methods.

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[8] For example, twelve watershed groups received federal 319(h) grant money to reduce sedimentation through public education, citizen monitoring and demonstration projects. These groups are coordinating activities through the Public Outreach and Education Subcommittee of the Sacramento River Watershed Program.

EXCESS SEDIMENTATION

Significantly impacts beneficial uses?	Yes. The Fall River (tributary to the Pit River) and Humbug Creek (tributary to the Yuba River) are on the 303(d) list as impaired due to excess sediment. Monitoring by local watershed groups and the Central Valley Regional Board indicates other tributaries are impacted by sediment.
Important issue in Sacramento River Watershed (technical)?	Yes. Sedimentation affects fisheries by limiting potential spawning grounds, smothers habitat for aquatic macroinvertebrates, and contributes to flooding. Elevated turbidity increases drinking water treatment costs.
Importance to Stakeholders (perception)?	Yes. Local watershed groups, Resource Conservation Districts (RCDs) and other stakeholders recognize sedimentation as a significant water quality problem. Sedimentation is raised as an issue in many 205(j) and 319(h) proposals submitted by local watershed groups to the State Water Resources Control Board
Important issue downstream?	No. High turbidity and sedimentation are not ecological water quality concerns in the Delta or Bay. Water column turbidity decreased and water clarity increased in the Delta, 1970 to 1993 (source: CALFED Water Quality Program Plan, Jan. 1998). If turbidity increases, it has the potential to be a drinking water concern.
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	Yes.
Have ability to make progress on issue?	Progress can definitely be made on this issue. Very clear best management practices have been developed for controlling erosion from different sources. Technical assistance and funding for implementation is available from several sources. Public awareness is high regarding occurrence of erosion and sedimentation.
Ongoing activities by others (cooperation or leverage possibilities)	Activities by others include programs conducted by local watershed groups addressing reduction of sedimentation, erosion control, and stream bank restoration. Agencies providing funding or working in cooperation with local groups include: RCDs, National Resource Conservation Service, Dept. Forestry, Dept. Water Resources, Dept. Fish and Game, State Water Resources Control Board, CALFED, county governments and University of California Range Management Program. Twelve local watershed groups received a 1999 319(h) grant to address sedimentation and are coordinating their efforts through the SRWP Public Outreach and Education Subcommittee.

Have expertise within group to move forward on issue?	The SRWP Toxics Subcommittee would need to recruit other stakeholders with expertise on this issue to become active members of the Subcommittee.
Are there regulatory considerations that encourage us to work on this issue now?	Regulatory considerations are few. Two waterbodies are on the 303(d) list. No water quality criteria exist for excess sedimentation.
Adequately being addressed by others?	Yes. This issue is receiving significant attention by local watershed stakeholder groups, CRMP (Coordinated Resource Management Planning) groups or conservancies, and RCDs. Sources of sedimentation are varied. Organization of interested parties to identify specific sources and to implement control practices is likely more effective if it occurs at a local level, than at a level covering the entire Sacramento River Watershed.

Evaluation prepared by Central Valley Regional Board staff, using the same criteria used by the SRWP Toxics Subcommittee to evaluate other water quality issues.

Water Quality Management Issue: Sediment Toxicity

Charlie Huang, California Department of Fish and Game
Janis Cooke, UC Davis Aquatic Toxicology Laboratory

Background

Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into surface waters. Mounting evidence exists of environmental degradation in areas where water quality criteria (WQC) are not exceeded, yet organisms in or near sediments are adversely affected (US EPA, 1994). It is becoming recognized that chemical analysis alone cannot provide sufficient assessment of the water quality significance of chemical constituents in aquatic sediments. This is because for many compounds, only a fraction of the total amount in sediment is in a toxic (bioavailable) form. Because relationships between concentrations of contaminants in sediment and their bioavailability are poorly understood, determination of contaminated sediment effects on aquatic organisms requires controlled toxicity tests (Burton and Ingersoll, 1994). Sediment toxicity tests can provide rapid information on the potential toxicity of contaminants to benthic organisms. Various methods have been developed to conduct sediment toxicity tests. The sediment phases evaluated may include whole (bulk) sediment and sediment elutriates[9]. Also sediment toxicity tests are conducted on the sediment pore waters. Whole sediment tests provide information primarily on the toxicity due to dissolved fraction of solid-phase exposures to benthic organisms. Elutriate tests can be used to evaluate the potential short-term effects of open-water in contact with sediment and the potential release of water-soluble constituents from sediment to the water column during movement of sediment and disposal of dredged material. Freshwater sediment samples can be analyzed for toxicity of bulk sediments to the amphipod *Hyalella azteca* and for toxicity of elutriate to the cladoceran *Ceriodaphnia dubia*. A Toxicity Identification Evaluation (TIE) has been developed for elutriate samples, and a draft TIE is being developed for bulk sediments. Saltwater sediment tests may use the amphipod *Eohaustorius estuarius* for bulk sediment testing and larvae of the mussel *Mytilus edulus* for elutriate evaluation.

I. PROBLEM STATEMENT

A few studies have shown that the Sacramento River Watershed (SRW) has several locations that contain contaminated sediments (Fujimura *et al.*, 1995; Domagalski, 1998). However, much of this information is fragmented among several unrelated studies. Along with the National Water Quality Assessment Program (NAWQA) results for the Sacramento River Basin, the USGS has completed a metal transport study in the Sacramento River that includes some sediment chemistry but no toxicity assays (Alpers, 1998). The San Francisco Bay Regional Monitoring

[9] To test a sediment elutriate, one part sediment and four parts site or control water are thoroughly mixed, sediment is allowed to settle, then the water is separated and used for toxicity testing.

Program monitors sediment chemistry and toxicity to bioassay organisms at one site on each of the lower Sacramento and San Joaquin Rivers, near Antioch (SFEI, 1997). Although sediment at some sites, such as reservoirs in mining areas, has been extensively analyzed, there has been no study incorporating toxicity testing at sites throughout the SRW.

A preliminary sediment toxicity study at selected Central Valley sites was conducted in 1995 (Ogle, 1998). In the study, *Hyalella azteca* was used to test toxicity of bulk sediment and *Ceriodaphnia dubia* to test sediment elutriate. Sediment samples from Cache Creek and Folsom Reservoir had no effect on either organism. Samples collected from the Sacramento River bed at Rio Vista and from Colusa Basin Drain decreased *Ceriodaphnia* reproduction, but were not toxic to *Hyalella*. Sediment from Sacramento Slough and Sump 111 (industrial/urban drain in Sacramento) significantly reduced survival of *Hyalella* and *Ceriodaphnia*. Other than organophosphate pesticides and possibly petroleum hydrocarbons, which likely caused toxicity of Sump 111 sediment, causative agents were not identified.

Sources

Contaminants of concern include certain heavy metals: copper, cadmium, zinc, and mercury from mining, agricultural, and municipal activities; as well as certain organics, such as polycyclic aromatic hydrocarbons, chlorinated hydrocarbon pesticides, organophosphate pesticides and polychlorinated biphenyls (PCBs). Preliminary chemical surveys in the NAWQA program suggest that sediments most highly contaminated with metals are closely associated with abandoned mines (i.e., acid mine drainage) or sites of the upper Sacramento River (Domagalski, 1998).

The main sources of organochlorine pesticides and PCBs are runoff and deposition from historical spills, movement of contaminated sediment and atmospheric deposition. Organophosphate pesticides have also been shown to accumulate in sediment. In recent studies in Crandall and Castro Valley Creeks, combining chemical analysis of sediment and toxicity testing with *Hyalella* , toxicity was correlated with levels of diazinon and chlorpyrifos in the sediment. *Hyalella* toxicity in these urban creeks was not related to metal concentrations. (Katznelson, 1998).

Sediment elutriates from the Sacramento and San Joaquin Rivers near confluence have been consistently toxic to *Mytilus edulus* larvae, 1991-1996. Sediment from the same sites is sometimes toxic to *Eohaustorius*. Toxicity to *Eohaustorius* is highly correlated with a value representing the cumulative contribution of sediment contaminants, suggesting that the effects of low-level contaminants present together should be considered, as well as higher levels of one or more contaminants, as potential causes of sediment toxicity. At the Sacramento River site, amounts of silver, chlordanes, fine particles, DDTs, copper and total organic carbon in sediment were associated with *Eohaustorius* mortality, whereas arsenic, chromium, mercury, selenium and hexachlorocyclohexanes were the least associated with toxicity (SFEI, 1997).

Areal Extent of Problem

According to the CDFG and USGS studies, several locations in the Sacramento River Watershed have been found to have contaminated sediments, including Keswick Reservoir, Sacramento River at Bend Bridge, Sacramento River at Colusa, and Sacramento River at Freeport.

Known Data Gaps

At this time, most of the sediment data available in the SRW, though limited, is from chemical analysis. The goals of further monitoring should be to fill data gaps on the toxicological and chemical characterization of sediments in the SRW. Combined with the sediment chemical data already collected by the NAWQA and continued by the SRWP, the results from sediment toxicity tests will give the regulatory and other agencies and stakeholders information on the occurrence and distribution of sediment characteristics in various parts of the SRW.

The effects of sediment contaminants on bioassay organisms in the laboratory have been studied in a very limited manner. Even less is known about the effects of sediment contaminants on native sediment organisms or aquatic communities in-stream. A few bioassessments of aquatic community health have been conducted in the Sacramento River Watershed (one is by the USGS National Water Quality Assessment Program, which will be continued by the SRWP), but results have not been compared with sediment toxicity or chemical analysis. Identification of toxic contaminants by correlating bioassessments or toxicity tests to sediment chemistry is difficult and requires a large number of samples and sites.

One other significant data gap is related to our lack of knowledge of sediment toxicity. Sediments in some parts of the SRW and the Delta contain large amounts of metals or organochlorine compounds, which may be resuspended by water and wind movement. The contribution of contaminants from sediment to water column toxicity is unknown. This information is needed, however, in order to develop remediation plans which will be the most effective at reducing toxicity from metals, organochlorines, or other sediment contaminants. Progress has been made on some water quality issues in the Sacramento River Basin. For example, a rice pesticide control program has been successful in reducing toxic levels of rice pesticides. Also, ongoing treatment programs at abandoned mines are decreasing the metal loads entering the Sacramento River. It is appropriate to focus attention on understanding sediment toxicity caused by past contaminants that have settled in and may be resuspended from sediments.

II. POTENTIAL SOLUTIONS/ACTIONS

Sediment toxicity testing should be conducted in order to screen for potential sediment toxicity problems. From this preliminary survey, decisions can be made whether to do follow-up studies in areas where problems are identified or to expand the survey to other unsampled areas. This information may contribute to the future development of sediment quality criteria in the SRW.

Goals are: 1) to identify contaminated sediment areas in the SRW; 2) to chemically analyze sediment from the areas found to be toxic; and 3) to conduct TIEs to identify the responsible constituents if toxicity is detected. The study will test hypotheses that sediments serve as reservoirs in which there are a wide variety of constituents that can cause toxicity. Information from this study will help to identify areas where sediment toxicity is significantly impacting the numbers and types of benthic organisms present in sediments, as compared to the organism assemblages that should be present based on habitat characteristics. This, in turn, is a starting point for further studies to assess whether the sediment toxicity is significantly adverse to the beneficial uses of a waterbody in which the sediments are located. Identification and assessment of the impacts associated with sediment conditions will provide information necessary to develop:

(a) viable monitoring programs,
(b) remedial actions protective of fish, wildlife, and water quality.

CALFED has already approved funding for Sediment Reuse and Toxicity Criteria for Delta. Purposes of this research are to: 1) determine whether Delta sediments are toxic to various components of the aquatic ecosystem, and 2) determine the beneficial reuse options for various types of Delta sediment.

The SRWP should begin to develop a workplan for sediment toxicity. During Year 1 of monitoring by the Sacramento River Watershed Program, sediment samples will be collected twice from nine sites in the Watershed for toxicity testing. Year 1 monitoring started in June, 1998. As part of the Year 2 Monitoring Plan, developed for 1999-2000, sediment samples will be collected from 10 sites in the Watershed below Shasta Lake and will be used for toxicity testing and analysis for metals and organic compounds.

As part of development of a sediment toxicity workplan, special attention needs to be paid to methods of sediment collection at the selected sites. Concentration and bioavailability of sediment contaminants depend to a large extent on particle size and type. Additionally, because wind and water flow may cause sediment to move differently from points across a creek or river channel, care must be taken to obtain a representative sample. Collection will likely involve extracting sediment from multiple spots and pooling to produce one sample. (Katznelson, 1998).

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SEDIMENT TOXICITY

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes, there is evidence aquatic life protection is impacted: Sediment in Keswick Reservoir is toxic to bioassay organisms. At the San Francisco Bay Regional Monitoring Program (RMP) Sacramento River site, at the very downstream end, sediment is toxic to bioassay organisms and to mussels transplanted to the site.
Important issue in Sacramento River Watershed (technical)?	Unknown.
Importance to Stakeholders (perception)?	Unknown.
Important issue downstream?	Maybe in the Delta. The San Francisco Bay RMP also found sediment samples from North and Central Bays are at times toxic to bioassay organisms. Chemical analysis of sediment and water suggests the Sacramento River Watershed is one source of metals and organic compounds (DDTs, chromium and mercury in particular).
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	No. At this point, we don't know whether we need a management strategy. More monitoring is needed, to identify sites and prioritize contaminants.
Have ability to make progress on issue?	Yes, we have the ability to further define the issue.
Ongoing activities by others (cooperation or leverage possibilities)	CALFED has funded wetland and channel restoration in Delta. Remediation of Keswick Reservoir sediment is planned.
Have expertise within group to move forward on issue?	Some. Could add others from Army Corp. of Engineers.
Are there regulatory considerations that encourage us to work on this issue now?	Toxicity to aquatic life violates the narrative objective of the Central Valley Regional Board's Basin Plan (concentrations of contaminants must be below levels that cause toxicity). USEPA is expected to issue a National Contaminated Sediment Strategy.
Adequately being addressed by others?	No.

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting.

Water Quality Management Issue: Temperature

Jerry Boles, Department of Water Resources - Northern District

I. PROBLEM STATEMENT

Water temperature has a direct effect on survival of aquatic life and habitat suitability. Extremes of temperatures, whether too warm or cold, and rapid changes in temperature produce adverse effects on aquatic life, such as aquatic macroinvertebrates and fish. Water temperatures are affected by alterations in flow caused by dams and diversions. Dams generally result in decreased downstream temperatures during the summer and increased downstream temperatures during the winter, while diversions which reduce downstream flow increase downstream temperatures during the summer and can result in decreased water temperatures during the winter. Water temperatures can also be affected by urbanization and forest and agriculture practices where trees providing shade along the riparian corridor are removed.

Temperature alterations affect aquatic macroinvertebrates by influencing their growth rate and emergence. These temperature alterations also influence the type of photosynthetic production (algae), which in turn affects the food web. During the summer downstream from dams, with cooler temperature, aquatic macroinvertebrates grow more slowly and take longer to develop to the terrestrial adult stage. Due to this delayed maturation, adults may emerge into the terrestrial environment when temperatures and other environmental conditions are not conducive to their survival. During the winter below dams, with warmer than normal temperatures, aquatic macroinvertebrates develop more quickly, which can result in emergence into terrestrial adults earlier than normal, which also may be when air temperature and other environmental conditions are not conducive to survival. Diversions have the opposite effects on aquatic macroinvertebrates, with warmer summer temperatures causing earlier development and cooler winter temperatures delaying development. Such conditions below dams or diversions often result in domination by only a few species. These opportunistic species develop very large populations due to lack of competition and predation from other species. While providing ample food supplies to fish during the short-lived aquatic life phase, the food base disappears when these few species emerge into the terrestrial adult life stage.

Chinook salmon are the most important fish species affected by altered temperatures below dams and from decreased stream flow due to diversions. Warmer temperatures from these habitat modifications affect all life stages. Adult immigration in the San Joaquin River has been found to be prevented by temperatures above 70 deg. F, but resumed when temperatures cooled to 65 deg. F. Adults held in hatcheries at temperatures greater than 60 deg. F have exhibited poor survival, and produced eggs which are less viable than those from fish held at cooler temperatures. Eggs incubated at temperatures greater than 60 deg. F have been found to exhibit high mortalities. Highest survival has been found in eggs from fish from the Sacramento River when incubated at temperatures ranging from 53 to 57.5 deg. F. Fry may successfully develop from eggs produced by adults held at high temperatures and incubated at lower temperatures, but the fry often exhibit poor survival. Fingerling Chinook salmon have a preferred temperature range of 53.6 to 57.2 deg. F, but acclimate to higher temperatures. The upper lethal limit for fingerlings in the Sacramento River has been determined to be 78.5 deg. F. Delayed mortality may occur in fish briefly exposed to high temperatures. Transformation to migratory smolts has been found to be inhibited at temperatures greater than 55 deg. F in steelhead trout and between 54 and 59 deg. F in coho salmon. A maximum temperature of 54 deg. F has been recommended to maintain migratory response and seawater adaptation for all species of salmonids.

While temperatures in the Sacramento River downstream from Shasta Dam may be cooler in the summer than they were prior to the construction of the dam, they are often still too warm for survival and successful reproduction of Chinook salmon. Prior to the construction of the dam, salmon migrated to the upper reaches of the Sacramento River, Pit River, McCloud River, and other tributaries upstream from the present dam, where temperatures are cooler. In tributaries to the Sacramento River, smaller dams and diversions block upstream migration to cooler water or cause downstream water temperatures to increase from decreased flow as a result of diversions, which create adverse water temperature conditions for aquatic life.

Rapid temperature changes also adversely affect aquatic life. Such temperature changes can occur from the sudden release of stored water behind dams for hydroelectric power generation or from industrial releases of cooling water. Aquatic organisms adapt to particular temperatures and can tolerate a range of temperatures that is dependent upon the adapted temperature. Sudden releases of warmer water outside the adapted temperature range do not permit adaptation to the higher temperatures, most often resulting in mortality of the aquatic organisms.

Higher than normal temperatures also produce other effects on aquatic organisms. Warmer temperatures lead to higher metabolic rates which require more food intake for maintenance. Yet higher temperatures may result in less availability of food organisms, which leads to decreased growth rates and survival of fish. Higher metabolic rates produced by higher water temperatures require higher oxygen intake, yet oxygen levels are inversely related to water temperatures. Warmer temperatures also adversely affect salmonids by increasing competition and predation by warm water species. Diseases affecting salmonids also become more prevalent in warmer water temperatures.

Type of Problem

Water temperature alteration is an aquatic ecosystem health concern.

Types of Sources

Water temperatures are affected by natural phenomenon, but may be most severe from development of various water control projects, including dams and diversions. Droughts and naturally decreasing summer flows usually result in elevation of temperatures. However, aquatic life has adapted to these natural conditions through development of life stages that avoid the unfavorable periods or migration to other areas that offer better conditions. Water control projects often produce effects to life stages that have not adapted to the artificially induced temperature regime, or block migration routes which force the aquatic species to remain in areas of unfavorable temperatures.

Extent of Problem

Artificially induced adverse water temperatures occur throughout the Sacramento River watershed. Typically, a dam or diversion either impounds water with minimal downstream releases or diverts water which decreases downstream flow, both of which lead to warmer water temperatures during the warmer parts of the year. The main stem of the Sacramento River has undergone temperature alteration from Shasta Dam, while smaller dams and diversions are prevalent on most tributaries. Much of the riparian corridor along the Sacramento River and many of the tributaries has been removed primarily due to agriculture and urbanization. Loss of shading from riparian cover results in direct solar heating of the water.

The Pit River is identified on the Clean Water Act 1998 303(d) list as impaired due to high temperatures.

Temporal Nature

The most severe water temperature problems occur during the warmer months, though warmer than normal temperature alterations during the winter can also adversely impact aquatic life, such as by altering the growth rate and timing of development of various life stages of aquatic insects.

Stakeholders

Those with a stake in the problems attributable to altered water temperatures include California Department of Water Resources, U S Bureau of Reclamation, U S Army Corps of Engineers, water contractors (municipal, agricultural, and industrial users), watershed groups, CALFED, U S Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Game, and sport and commercial fishermen.

Data Gaps

The temperature regimes in tributaries are poorly known. Also lacking is information regarding impacts of temperature during the life stages of key fish species. For example, Chinook salmon have been well studied, but optimal temperature requirements of steelhead at all life stages are not known.

Research is needed on the effects of temperature variations. Some data have been gathered by various organizations in some tributaries, but these data are generally short term or only cover a limited reach of the stream. Critical temperature limits for fish or other aquatic organisms have been determined in the laboratory using constant temperature conditions. In natural environments, water temperatures may exceed critical limits during the day, but cool to below these limits during the night. The effect of this temperature variation on critical limits has not been investigated.

II. POTENTIAL SOLUTIONS/ACTIONS

Additional temperature data from tributaries should be collected. Temperature-related problems below dams and diversions may be mitigated by increasing low flows, releasing water from lower depths from reservoirs, and removing unneeded diversions and dams. Temperature and ecosystem health information may be collected and forwarded to agencies having authority over operations of dams and diversions, including US Bureau of Reclamation, CA Department of Water Resources and US Army Corps of Engineers.

Increased water temperatures due to solar heating can be mitigated by replanting riparian species to provide shade along the river as well as habitat for a variety of wildlife species, some of which contribute to the aquatic food web.

Other Agencies Involved in Temperature Management

The 1992 Central Valley Project Improvement Act (CVPIA) set an ambitious goal of "making reasonable efforts to ensure that, by 2002, natural production of anadromous fish in Central Valley rivers and streams... at levels not less than twice the average levels attained during 1967-1991". Efforts are being led by the US Fish and Wildlife Service (USFWS), as directed in the Anadromous Fish Restoration Program (AFRP). Anadromous fish species of concern in the Sacramento River Watershed are Chinook salmon, steelhead trout, American shad, striped bass, green sturgeon and white sturgeon. Temperature management is among the proposed restoration project categories. Specific actions identified in the AFRP are: maintain temperatures at 56 deg.. F or less in the Sacramento River from Keswick Dam to Bend Bridge; develop and utilize a temperature management model for the Feather River; provide suitable water temperatures and flows for all salmonid life stages in Bear, Calaveras and Mokelumne Rivers. In fiscal year 1996 and 1997, $11.8 million was allocated for restoration actions, primarily property acquisition and riparian habitat and channel restoration, and monitoring projects. For fiscal year 1998, six to ten million dollars worth of possible projects have been identified. Thus far in implementation of the AFRP, temperature management actions have not been conducted. (Information from the AFRP web page: www.delta.dfg.ca.gov/usfws/afrp/cvpia.html and the "Handbook of Regulatory Compliance for the Anadromous Fish Restoration Program" published by USFWS).

TEMPERATURE

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes. Sites suitable for salmon spawning and larval growth are limited, in part, by temperature. Sacramento River winter run Chinook salmon are endangered; Central Valley steelhead are threatened. Classification on the federal Endangered Species list is proposed for spring, fall and late fall runs of Chinook salmon (spring run are on the state threatened species list).
Important issue in Sacramento River Watershed (technical)?	Yes. Central Valley Improvement Act directs that by 2002, natural production of anadromous fish species should be doubled. Agencies with programs to increase habitat and conservation include: Dept. Water Resources, Dept. Fish and Game, US Fish and Wildlife Service and CALFED.
Importance to Stakeholders (perception)?	Yes, because of the effect on fish.
Important issue downstream?	Yes, because of impact on fisheries and indirect ecosystem effects (declines in certain invertebrate or fish species causes alterations in other parts of the food web).
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	Yes.
Have ability to make progress on issue?	Yes, especially in tributaries. New temperature curtains in Lake Shasta and Whiskeytown Reservoir should allow better adjustment of the temperature of water pumped out of these reservoirs.
Ongoing activities by others (cooperation or leverage possibilities)	CALFED is funding projects to protect fish and enhance habitat. Other agencies with activities: Dept. Water Resources, Dept. Fish and Game, US Fish and Wildlife Service, US Bureau of Reclamation and local conservancies or CRMP groups.
Have expertise within group to move forward on issue?	The Toxics Subcommittee would need to recruit people with expertise on the temperature issue to be active participants of the Subcommittee.
Are there regulatory considerations that encourage us to work on this issue now?	Central Valley fish species are listed on both the federal and state Endangered and Threatened Species lists. Central Valley Regional Water Quality Control Board Basin Plan's temperature objective for Sacramento River from Shasta Dam to I Street Bridge is violated at times in spring through fall. DFG has requested that the Regional Board amend the Basin Plan to include temperature objectives for tributaries. The State Water Resources Control Board's Thermal Plan is being reviewed; it currently is not used

	for inland streams (Thermal Plan's objective for cold water streams is zero degree temperature increase in the receiving water below a discharge)
Adequately being addressed by others?	The Anadromous Fish Restoration Program is providing money and implementing projects to achieve the CVPIA goal. We may not need to develop our own management strategy.

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting.

Water Quality Management Issue: Toxicity of Unknown Origin

Valerie Connor, Central Valley Regional Water Quality Control Board

Background:

A toxicity test is a laboratory procedure to determine the toxicity of a water or sediment sample using a test species. Protocols have been developed and promulgated by US EPA for both fresh and salt water species (fish, invertebrates and algae) in both water and sediment samples. In a toxicity test, field samples are collected, brought back to the laboratory and the test species is introduced to the field sample. Survival or other end points (i.e., measures of growth or reproduction) are monitored for the duration of the test. Essentially, the tests ask the test species if they can live, grow or reproduce in a site sample. Toxicity is suggested when a test species performance is statistically different than performance in a clean laboratory control. The tests are one way to assess compliance with the narrative standard of "no toxics in toxic amounts", which is part of each Regional Board's Water Quality Control Plan (Basin Plan). The tests are useful because they indicate that the test species do not survive (or performs less well) in site water. However, the test does not indicate why toxicity occurred. Chemical monitoring and a Toxicity Identification Evaluation (TIE) are used to determine the cause of toxicity. The TIE is a set of procedures designed to identify the specific causative agents responsible for the observed toxicity. "Unknown toxicity" or "toxicity of unknown origin" refers to the situation where toxicity has been detected, but a TIE either has not been performed or has not successfully identified a toxicant. "Unknown toxicity" suggests a water quality problem exists for aquatic organisms and is also a violation of the narrative standard; therefore it is a regulatory problem. To eliminate the toxicity from the location where sampling occurred it is useful to know the specific chemical cause and the source(s). Once this information has been determined, management strategies can be implemented to eliminate the observed toxicity.

CALFED has included "toxicity of unknown origin" in its Water Quality Program Actions. Specifically, to "identify parameters of concern in the water and sediment within the Delta, Bay, Sacramento River and San Joaquin River regions and implement actions to reduce their toxicity to aquatic organisms". The Water Quality Program suggests that this be done by: (1) determining the extent of toxicity in water and sediments; (2) identifying toxicants; (3) determining sources of toxicants; (4) developing techniques and protocols for toxicity bioassays for indigenous species; and (5) evaluating source control measures.

This document summarizes the locations and test species for which there is existing information on toxicity of unknown origin. It then summarizes the methods which have proven successful in the past in determining the contaminants responsible for the observed toxicity. Specifically, this document focuses on contaminant identification. Specific strategies for toxicant control are not presented. Once a contaminant is identified, it is assumed that it will fit into one of the categories (metals, pesticides, etc.) for which implementation strategies are already being developed.

This document does not focus on the species for which we do not have toxicity information. Development of protocols for toxicity testing with indigenous species is a critical need. Also, this document does not focus on locations where we do not have toxicity information. Most of the toxicity testing conducted over the past ten years has focused on the main stem rivers below the major reservoirs. More comprehensive monitoring programs that include critical habitats and the tributary watersheds to the Delta should be implemented. Toxicity testing has been done in order to develop or confirm water quality objectives for particular constituents in parts of the watershed (e.g., metals in the Sacramento River between Lake Shasta and Hamilton City). Since it is not due to "unknown" causes, this type of toxicity testing will also not be discussed.

I. PROBLEM STATEMENT

Since 1986, the CVRWQCB and CDFG have been testing the surface waters of the Central Valley for toxicity (see reference list) using USEPA-recommended three species bioassays. Starting in 1996, the SRWP has participated in toxicity testing in the Sacramento River and some tributaries. Sediment testing has also occurred, but on a much more limited basis. The freshwater aquatic test species recommended by US EPA are the fathead minnow, *Ceriodaphnia dubia* (a cladoceran) and *Selenastrum capricornutum* (a unicellular green algae). In addition to testing with these species, limited testing has been performed using striped bass and species native to the Watershed, including rainbow trout and two invertebrates, *Neomysis* and *Brachionus*. The freshwater species used in bulk sediment toxicity testing are *Hyalella azteca* (an amphipod) and *Chironomus* (a midge). Sediment elutriate tests are frequently performed using *Ceriodaphnia*.

The Regional Monitoring Program for San Francisco Bay has also conducted toxicity testing in the Delta and Bay. In brackish and salt water, a number of test species can be used. Unknown toxicity has been detected using *Mysidopsis bahia* (mysid shrimp) and *Mytilus edulus* (mussel). In sediment bioassays, significant amounts of unknown toxicity has been detected using *Eohaustorius* and *Mytilus*. Since the start of bioassay testing by RMP in the early 1990s, water samples from the Sacramento and San Joaquin Rivers near confluence and from the northern Bay were toxic to *Mytilus* in half of the bioassays, but were rarely toxic to *Mysidopsis* (SFEI, 1997). Causes of *Mytilus* toxicity are unknown

Unknown toxicity is of significant concern because it indicates that there exist agents which are bioavailable and causing toxicity that remain to be identified. Unknown toxicity is also an issue for the Sacramento River Watershed and the Delta because it leads to these water bodies not being in compliance with the Narrative Toxicity Objective of the Basin Plan. A number of stakeholders are interested in resolving the issue of unknown toxicity, including regulatory agencies, point and non-point source dischargers, environmental advocates, farmers, miners, water supply agencies and the general public.

Extent of Problem

In approximately half of the toxicity tests conducted in the Sacramento River watershed, the toxicity detected with these test species has not been linked to specific chemicals. This is also true for approximately 30% of the toxic samples collected in the Delta and the San Joaquin River Watershed. The entire Delta, reaches of both the Sacramento (from Shasta Dam to Red Bluff and from Colusa Basin Drain to the Delta) and San Joaquin Rivers and several tributaries are listed as impaired on the Clean Water Act 303(d) list for "unknown toxicity". Specific tributaries on the 303(d) list are: the lower American River, lower Feather River, Cache Creek and Colusa Basin Drain.

Known Data Gaps

Where toxicity has been detected, there are several other things that need to be determined before control strategies can be implemented. The specific contaminates must be identified. Once identified, the duration, magnitude and frequency of contamination need to be determined. Sources and the practices or actions which allow the toxicants to enter receiving waters must also be identified.

There is a lack of knowledge about the ecological impacts of the unknown toxicity that are identified with selected bioassay species. Limited bioassay testing has been done with native species.

Toxicity testing has not been conducted throughout the watershed. To date, the focus has been in the major tributaries and downstream of the major reservoirs.

The toxicity testing conducted by the Regional Monitoring Program has used marine species in fresh water samples from the Delta and lower Sacramento River. Once the cause of toxicity is identified, the impact of salinity added during the testing must be evaluated.

II. POTENTIAL SOLUTIONS/ACTIONS

Both the CVRWQCB and San Francisco Regional Monitoring Program have long-term toxicity monitoring programs to monitor toxicity in the Sacramento River, San Joaquin River, Delta and San Francisco Bay. Recently, the Sacramento River Watershed Program began a toxicity monitoring program for the Sacramento River Watershed. DeltaKeeper is about to initiate a monitoring program for the Delta.

Ideally, when toxicity is detected, a TIE is performed and a causative agent is identified. Once a chemical is identified, it can be monitored in the field to identify its source and to characterize its spatial and temporal distribution. This information, along with concentration data, can be compared to values in the toxicological literature to provide a rough estimate of ecological risk.

This is the process that was used for several of the chemicals that are surface water contaminants of concern in some waterways.

CALFED has provided funding to the Central Valley Regional Water Quality Control Board to follow-up on the unknown toxicity fathead minnows and *Selenastrum* observed in water samples from the Sacramento River Watershed. The SRWP, through the Toxics Subcommittee, will advise the design and performance of these studies and should begin to develop workplans.

Work should begin immediately on determining the cause of toxicity exhibited by other species. Specifically:

- *Ceriodaphnia* toxicity occurs throughout the Central Valley and Delta. Chronic toxicity has been detected over large geographic areas and over several months. The toxicity is detected at critical times and locations, when larval fish feed on invertebrate populations that could decline due to effects of toxicants.
- *Ceriodaphnia* chronic toxicity is commonly detected in water supplies and effluents that originated as ground water. As we begin relying more on ground water supplies it is essential to determine why this water frequently causes chronic toxicity to *Ceriodaphnia.*
- Striped Bass toxicity tests conducted during the late 80's and early 90's indicated significant toxicity in the Sacramento River. Striped Bass testing should resume during their spawning season at all locations where eggs and larvae occur.
- Rainbow Trout embryo larval tests were recently initiated in the Sacramento River Watershed. Acute mortality was observed at locations dominated by urban storm run off. Testing should be resumed and should focus on critical habitats and critical periods for salmonid spawning.
- *Neomysis* has been used as a test species intermittently in the Sacramento River Watershed, the Delta and other freshwater habitats characterized by high conductivity. *Neomysis* is an important food species for larval fish. Testing needs to be resumed.
- The RMP has detected significant amounts of toxicity in their RMP. Much of the toxicity appears to originate in tributaries to the Delta. Sediment toxicity is persistent. The RMP efforts should be supplemented with sufficient resources to characterize the toxicity that has been detected.

Coordination with ongoing programs is possible and essential. Monitoring programs should be developed for each condition listed above. The programs should be multi-year programs. The first year would focus on characterizing the toxicity spatially and temporally. Contaminant identification work should also be initiated. The second year should focus on contaminant identification. The third year should focus on confirmation .

Determining the chemical(s) responsible for toxicity requires using all the information available. Work would occur simultaneously in all of these areas:

- Conduct a Toxicity Identification Evaluation (TIE):

Phase I: Determine the general class or characteristics of the toxicant (Is it a metal or an organic compound, is it volatile, filterable or sublatable)
Phase II : Determine the specific chemical(s)
Phase III : Confirm the chemical(s)

- Determine spatial and temporal variability of toxicity
- Determine the source of toxicity
- Examine land use in the watershed to determine potential contaminants: For example, if agricultural land use: Look at cropping patterns and pesticide/fertilizer application patterns. Work with County agricultural commissioner, DPR, DPR pesticide use reports, farm advisors, pesticide applicators and growers
- Consider species sensitivity: This involves looking at the toxicological literature to determine relative toxicity of potential contaminants (seeing if species which is exhibiting toxicity is sensitive to potential contaminants and if it is more sensitive to potential contaminants than species not exhibiting toxicity). This also involves consideration of additivity or synergism of multiple toxicants.
- Work with analytical support: Frequently samples contain compounds below recording limits or contain unknown peaks. Analytical laboratories can work to lower detection limits and identify unknown spikes. This must be closely coordinated with TIE work.
- Consider factors besides contaminants: salts, minerals, physical factors (high TSS), biological factors (pathogens) and that apparent toxicity may be due to a deficiency of a physiologically required element (i.e. poor performance in a very soft water).

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UNKNOWN TOXICITY

CRITERIA	EVALUATION
Significantly impacts beneficial uses?	Yes. Delta waterways, the lower American River, Cache Creek, Colusa Basin Drain, the lower Feather River, and the Sacramento River from Shasta Dam to Red Bluff and from Colusa Basin Drain to the Delta are identified as impaired on the 303(d) list as impaired due to unknown toxicants. Also, toxicity seen in the Sacramento River and tributaries is a violation of the Central Valley Regional Water Quality Control Board's Basin Plan narrative objective, which requires contaminants be below levels which cause toxicity to aquatic organisms.
Important issue in Sacramento River Watershed (technical)?	Yes.
Importance to Stakeholders (perception)?	Yes, to some stakeholders. Others are probably not aware of the problem.
Important issue downstream?	Yes. There is unknown toxicity in the Delta.
Do we (SRWP Toxics Subcommittee members) generally agree on the problem?	Yes. The first step is to identify the agents causing aquatic toxicity. It is likely that causes are different in different waterbodies. After causative agents are determined, further progress in identifying sources and developing management strategies will occur under the appropriate water quality issue of concern.
Have ability to make progress on issue?	Yes. The SRWP monitoring plan includes toxicity testing and follow-up evaluation of toxic samples to identify the causative agent. SRWP has the ability to fill data gaps.
Ongoing activities by others (cooperation or leverage possibilities)	Funding to investigate unknown aquatic toxicity is being provided by CALFED. Organizations conducting toxicity testing and toxicity identification evaluations include DeltaKeeper, the joint University of California Davis, State Water Resources Control Board and Central Valley Regional Board Toxicity Program, and the Regional Monitoring Program of the San Francisco Estuary Institute. Toxicity testing information is also available from NPDES permittees.
Have expertise within group to move forward on issue?	Yes.

Are there regulatory considerations that encourage us to work on this issue now?	Yes. There are waterbodies listed as impaired on the 303(d) list, and incidences of aquatic toxicity violate the Central Valley Regional Board Basin Plan.
Adequately being addressed by others?	No.

Evaluation prepared by members of the Toxics Subcommittee at their July 22, 1998 meeting.

SRWP Toxics Subcommittee Recommendations

Rationale for Recommending Mercury Bioaccumulation and Organophophate Pesticide Toxicity as Priority Issues for Development of Water Quality Management Strategies

Mercury and organophosphate pesticide toxicity were suggested by the SRWP Toxics Subcommittee to be the first two issues for which water quality management strategies will be developed. Reasons behind these recommendations are summarized below.

Mercury

1. Mercury bioaccumulation is a significant human health concern in the Sacramento River Watershed right now. Fish consumption advisories exist for waterbodies in the Sacramento River Watershed and the Delta and San Francisco Bay. Recent data suggest that mercury concentrations in fish from other waterbodies may be above levels safe for human consumption, but more samples are needed (Domagalski, 1998; SRWP, 1998). Protection from neurotoxic effects of mercury is likely inadequate, particularly among children, pregnant women and people who eat large amounts of mercury-laden fish.

2. Mercury is an ecosystem health concern. Mercury concentrations in fish and birds in the Cache Creek Basin indicate fish-eating birds and other wildlife may be experiencing reproduction harm due to mercury (estimation by US Fish and Wildlife Service). Sensitive bird species in the northern Delta-Estuary may also be at risk for mercury toxicity (SFBRWQCB, 1998).

3. The Sacramento River Watershed is a substantial source of mercury entering the Delta-Estuary. Four major sources of mercury have been identified for the Delta: mercury lost during gold mining in the Sierra Nevada Mountains, abandoned mercury mines and natural deposits in the Coast range, resuspension from sediment, and municipal and industrial discharges (the smallest source). Net influx of mercury from the Sacramento River Watershed to the Estuary in a year of average water flow is estimated to be 200 kg (SFBRWQCB, 1998). In wet years, runoff, erosion and sediment movement increases the net influx to an estimated 600-800 kg/year (Larry Walker Associates, 1997; Foe et al, 1997).

4. There are research and monitoring efforts currently underway to determine particular sources, mercury loads, likelihood of mercury deposits to become bioavailable and other data gaps. The SRWP Toxics Subcommittee recommends that for developing management plans, the SRWP collaborate with other groups addressing the same water quality problem. This would increase the numbers of stakeholders involved and stretch SRWP's dollars. Research and monitoring is being done under the Superfund Cleanup Program at Clear Lake, by the UC Davis Mercury Workgroup, through the Cache Creek Stakeholders group and Yolo County for Cache and Putah Creeks, by the San Francisco Bay Regional Monitoring Program, by the San Francisco Bay and Central Valley Regional Water Quality Control Boards, US Geological Survey, and US Fish and Wildlife Service. Funding may be available from the Clean Water

Act 104(b)(3), 106(g) and 319(h) grants, CALFED and USEPA. Some work on management options has already been initiated by potential collaborators. Mercury control strategies have been proposed by the San Francisco Bay and Central Valley Regional Water Quality Control Boards and the Sacramento Regional County Sanitation District. The Central Valley Regional Water Quality Control Board has proposed to USEPA that mercury control efforts in the Cache Creek Basin be the basis for the first mercury TMDL (total maximum daily load, see Abbreviations page) developed in the Central Valley.

5. The mercury water quality problem is persistent. Mercury cycles through environmental compartments and is not eliminated from the environment naturally. New mercury enters waters of the Sacramento River Watershed and Estuary yearly. Despite the interest in controlling mercury levels, the only mercury management programs currently in place in the Sacramento River Watershed are localized to a few of the abandoned mercury mines.

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Organophosphate Pesticide Toxicity

1. Toxicity of organophosphate (OP) pesticides is a significant water quality problem throughout the Sacramento River Watershed. The Pesticides Issue Summary details recent studies showing toxicity of water samples to aquatic bioassay organisms. Toxic levels of OP

pesticides are routinely detected in agricultural runoff, urban runoff, wastewater treatment plant effluents, rain and fog (Connor and Deanovic, 1999; Domagalski, 1998; Foe et al., 1998; Holmes et al., 1998; Katznelson and Mumley, 1997; Kuivila and Foe, 1995). Toxicity has been found in some agricultural drains, sloughs, urban creeks, the Feather River, Sacramento River and throughout the Delta. Toxicity to aquatic invertebrates is hypothesized to reduce the availability of food for young fish, including endangered and fish species of concern.

2. There are multiple sources of organophosphate pesticides. Control strategies for some sources, such as developing and testing agricultural best management practices, educating urban users about the effects of pesticides in urban runoff, and creation of urban Integrated Pest Management Programs, can be effectively implemented through a stakeholder-based organization.

3. Opportunities exist now for collaboration on the issue of OP pesticide toxicity. The Department of Pesticide Regulation is currently coordinating self-regulatory, cooperative efforts to identify and implement site-specific practices to reduce risk of contamination of OP pesticides used as orchard dormant sprays. If OP pesticide toxicity still occurs after the dormant spray season in Winter 2001-2002, agency-imposed regulatory controls will be enacted. Efforts to control urban pesticide runoff are also in a stage of needing stakeholder participation. At this point in the urban pesticide strategy, Dept. Pesticide Regulation is encouraging education and outreach efforts to communicate pollution prevention strategies.

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In comparison with other water quality issues, mercury and organophosphate pesticide toxicity stand out regarding the severity of these problems and the opportunities for SRWP to make clear progress in improving water quality in the Watershed. Additionally, sources and/or problems caused by these water contaminants occur throughout the Sacramento River Watershed. Please refer to the evaluation tables for aspects of other water quality issues that caused the Toxics Subcommittee to recommend mercury and organophosphates. The major consideration in not recommending each of the other water quality issues for the Toxics Subcommittee's first management efforts is described briefly here.

Bioaccumulation of organochlorines and PCBs.   The ability to significantly reduce levels of PBCs and organochlorines is unknown because of the large proportion of these compounds already present in bottom sediments and because most of these substances are already banned from use in the United States.
Excess nutrients.   Water quality problems due to excess nutrients are very localized, rather than being widespread across the Watershed.
Metals.   Metals do not appear to be a significant water quality problem, except for streams affected by acid mine drainage and copper in San Francisco Bay. Other metals impairments need to be identified.
Sedimentation.   Sedimentation control efforts at smaller watershed levels appear effective. There may be other ways the Toxics Subcommittee could assist these efforts, rather than developing its own management strategy.
Sediment toxicity   More information is required to identify sites in the Watershed where sediment contamination is causing toxicity to aquatic organisms.
Temperature.   The ability of SRWP to improve water temperatures is unknown. There are localized, watershed-specific solutions being designed or implemented in some smaller watersheds. Temperature in the mainstem Sacramento River is largely controlled by contolling temperature of water released from Shasta Dam.

The SRWP Toxics Subcommittee recommends that progress in issues of drinking water parameters of concern and toxicity from unknown sources be tracked and new information gathered. This recommendation is explained in the next section.

SRWP Toxics Subcommittee Recommendations

Recommended Priority Parameters for Data Acquisition: Drinking Water Quality Parameters and Unknown Toxicity

The SRWP Toxics Subcommittee recommends that the Subcommittee focus special attention on two other water quality issues, drinking water constituents and aquatic toxicity from unknown sources. Unknown toxicity includes impacts to water column and sediment-dwelling organisms. These are also considered priority water quality issues of concern. Additional information is needed, however, in order to identify particular agents causing water quality problems and to determine whether management strategies are currently needed.

Unknown constituents cause toxicity to aquatic life in the Sacramento River and tributaries, but causes of the toxicity need to be identified. The Toxics Subcommittee is advising the Central Valley Regional Water Quality Control Board regarding two studies to investigate causes of unknown toxicity to two bioassay species, fathead minnows and green algae. These studies are funded by CALFED.

Drinking water constituents of organic carbon, turbidity, dissolved solids and algal blooms are not currently major concerns for drinking water users in the Sacramento River Watershed. Pathogens are of concern in some areas heavily used for contact recreation but are controlled in treated drinking water. Sources and waterbodies impacted most severely by drinking water contaminants also need to be identified. Monitoring data for these parameters should continue to be analyzed by the Toxics Subcommittee, to determine whether drinking water quality problems are increasing in severity.